

## Cement Requirements for Some Concrete Mixes

*The tables in this article will be of value to every contractor and engineer. They show the cement required for a wide range of mixes, using a variety of aggregate gradings.*

*They are the only tables available which are based on sand weighing from 100 to 110 pounds per cubic foot.*

*All of the commonly used mixes as well as some of the odd fractional mixes that are now being used, are included.*

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ONE of the most important factors to be considered in the cost of concrete is how much cement will be required per cubic yard.

Specifications sometimes set the mix to be used and also the minimum number of barrels of cement to be used per cubic yard of concrete. Since the cement content will vary with the gradation of the aggregates used, this practice usually results in confusion. Either the mix must be revised to such proportions that the resulting concrete will contain the required number of barrels of cement, or the given mix must be used with the resulting cement content being greater or smaller than that required, as the case may be.

Revision of the mix or the use of the specified mix if it results in the use of more cement than is called for in the specifications usually brings a protest from the contractor. The use of a smaller cement content than specified is objectionable to the engineer who is trying to get the best work possible for the money.

This situation could be relieved if the minimum cement content for a given mix were specified. This value should

be based on experimental data. The cement content or yield should be determined for a given mix, using aggregates which are as coarse and as fine as the specifications permit with several intermediate points. From the resulting data the proper cement factor could be specified.

In this paper the data resulting from such a series of tests are presented. The object of the tests was to determine the maximum and minimum cement factors for the mix as specified in the 1926 Kansas State Highway Specifications.

The gradation of the coarse aggregate was the only variable in the tests on sand and stone concrete.

Throughout the paper the term "yield" means the barrels of cement required to produce one cubic yard of fresh concrete.

The first determinations made were for the three standard mixes used in highway and building work—namely, 1:3:5, 1:2:4 and 1:2:3½. In addition to the above the yields of 1:1¾:3½, 1:1¾:3¾ and 1:2½:4¾ mixes were investigated. All concrete was proportioned by dry and rodded volume.

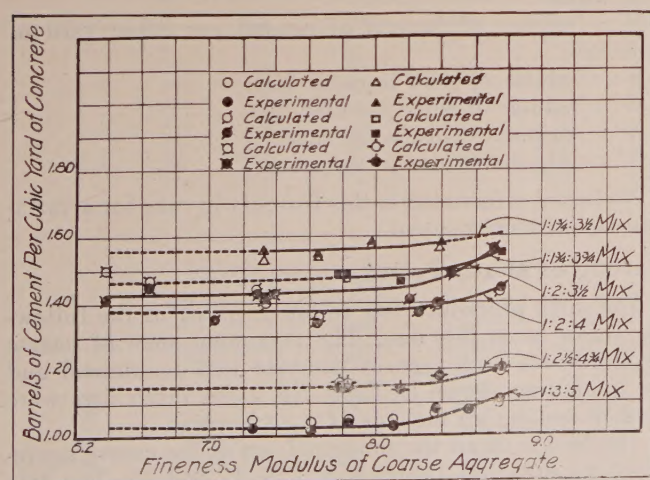


Figure 1

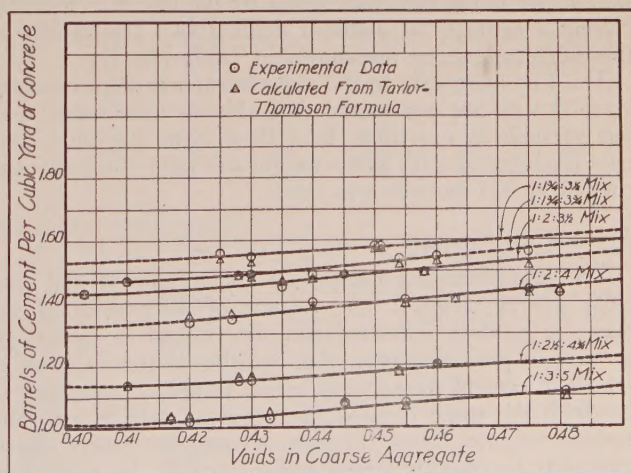


Figure 2

Grading of Aggregates

The gradation of the coarse aggregate was based on Table No. 1 taken from the Kansas State Highway Specifications for 1926.

| TABLE NO. 1                    |                                         |       |        |       |             |                                   |                        |
|--------------------------------|-----------------------------------------|-------|--------|-------|-------------|-----------------------------------|------------------------|
| Max. size<br>of ag-<br>gregate | Per Cent Retained on Square Mesh Sieves |       |        |       |             | Percent. Passing<br>Not More Than |                        |
|                                | 2½-in.                                  | 2-in. | 1½-in. | 1-in. | ¾-in.       | ¾-in.                             | 4-mesh<br>gravel stone |
| 2½-in.                         | 0-5                                     |       | 25-75  |       |             |                                   | 90 95                  |
| 2-in.                          |                                         | 0-5   |        | 25-75 |             |                                   | 90 95                  |
| 1½-in.                         |                                         |       | 0-5    |       | 25-75       |                                   | 90 95                  |
| 1-in.                          |                                         |       |        | 0-5   | Not over 60 |                                   | 90 95                  |
| ¾-in.                          |                                         |       |        |       | 0-5         |                                   | 90 95                  |

In order to produce the gradation of coarse aggregate required, the following procedure was carried out. A good quality of local crushed limestone was graded into given sizes and each size was placed in a separate bin. This method made it possible to prepare sufficient material to carry out the complete experiment.

The bins containing the different sizes of stone were designated as shown in Table No. 2.

| TABLE NO. 2 |                      |                              |  |
|-------------|----------------------|------------------------------|--|
| Bin No. 1   | Passing 3-in. sieve  | and retained on 2-in. sieve  |  |
| Bin No. 2   | Passing 2-in. sieve  | and retained on 1½-in. sieve |  |
| Bin No. 3   | Passing 1½-in. sieve | and retained on 1-in. sieve* |  |
| Bin No. 4   | Passing 1-in. sieve* | and retained on ½-in. sieve* |  |
| Bin No. 5   | Passing ½-in. sieve  | and retained on ¼-in. sieve* |  |
| Bin No. 6   | Passing ¼-in. sieve  |                              |  |

\*Round.

The first determinations were made using a 1:3:5 mix or concrete which would ordinarily be used in base course concrete for pavements or for mass concrete in structures. The maximum size of coarse aggregate for this kind of concrete would be 2 or 2½ inches. Seven gradations were chosen, all of which would meet the specifications for these two maximum sizes.

A batch weighing 50 pounds of each gradation was made up. The mechanical analysis and the weight per cubic foot of each batch were found. The standard fineness modulus sieves were used for mechanical analyses. In making the analyses, the total batch of 50 pounds of stone was sieved to avoid any errors in sampling. The weight per cubic foot was found by the use of a measure having a capacity of one-half cubic foot. The results of these determinations are shown in Table No. 4.

The fine aggregate in the experiment was kept constant since it was not considered desirable to have more than one variable at one time. Kaw River sand having a fineness modulus of 2.65 and a weight per cubic foot dry and rodded of 111 pounds was used.

Measuring Volume

The procedure for measuring the volume of the concrete was as follows: The volume of 50 pounds of the stone of gradation desired was determined by means of the weight per cubic foot. The weights of the volumes of sand and cement were found which would be necessary to use with the stone to produce the given mix by dry and rodded volume. These weights of fine and coarse aggregate were thoroughly mixed and the weight per cubic foot of the mixture was found. The cement was then added and the batch was mixed dry. The water was added and

the weight of water used to produce the desired consistency was recorded. After the concrete was mixed, a ½ cubic foot measure was filled and the weight of concrete necessary to fill it was determined. From this data the yield was calculated since the volume of the batch is to its weight as the volume of the measure is to the weight of the concrete in it. The solution of this proportion gives the volume of the batch and since the quantity of cement necessary to produce that volume of concrete is known, the quantity necessary to produce a cubic yard can be calculated. A sample calculation is shown for Batch No. 1.

$V_b$  = Volume of the Batch  
 $V_m$  = Volume of the Measure  
 $W_b$  = Total weight of the materials in the batch including the water  
 $W_m$  = Weight of concrete in the measure  
Then  $V_b:V_m::W_b:W_m$   
$$V_b = \frac{V_m W_b}{W_m} = 0.5 \frac{W_b}{W_m}$$
  
for Batch No. 1  $V_b = \frac{0.5 \times 111.9}{74.25} = 0.75$  cubic foot.  
 $\frac{11.6}{94} = 0.123$  cubic foot of cement were required to produce 0.75 cubic foot of concrete.

$$\text{Barrels per cubic yard} = \frac{0.123}{0.75} \times \frac{27}{4} = 1.11$$
  
Reducing the last equation to more general terms we have:

$$\text{Barrels of cement per cubic yard of concrete} = \frac{\text{Volume of cement}}{\text{Volume of batch}} \times 6.75$$

No effort was made to control the water cement ratio and the values recorded are determined from the amount of water necessary to produce what seemed to be in the judgment of the operator a consistency which would be used in the field. The consistency was measured by means of the standard slump cone.

The calculated yield was found from Taylor and Thompson's formula:

$$B = \frac{27}{2.61 + 1.34(1-V)S + 1.08(1-V^1)G}$$
  
in which  
 $B$  = Number of barrels of cement per cubic yard of concrete  
 $S$  = Volume of sand in cubic feet  
 $G$  = Volume of stone in cubic feet  
 $V$  = Absolute voids in the sand  
 $V^1$  = Absolute voids in the stone.

No factor is included in this formula to care for a variation in the water content.

Variety of Mixes Tested

The same procedure was followed in all of the following series as in this one. The maximum sizes of coarse aggregate for each type of concrete was determined and the gradations shown in Table No. 1 for those sizes were used in making up the stone for each series.

The results of all the sieve analyses of the coarse aggregates are shown in Tables 3, 5, 7, 9, 17 and 13. The data on the concrete produced are given in Tables 4, 6, 8, 10, 12 and 14.

TABLE NO. 3 (1:3:5 SERIES)  
Gradation of Coarse Aggregate

| Batch No. | Pounds of Stone |           |           |           |           |           | Total | Sieve Analysis—Per Cents Retained— |        |       |       |       | F. M. |
|-----------|-----------------|-----------|-----------|-----------|-----------|-----------|-------|------------------------------------|--------|-------|-------|-------|-------|
|           | Bin No. 1       | Bin No. 2 | Bin No. 3 | Bin No. 4 | Bin No. 5 | Bin No. 6 |       | 2-in.                              | 1½-in. | ¾-in. | ⅜-in. | 4-in. |       |
| 1         | 20              | 17.5      | 12.5      | 00.0      | 0.0       | 0.0       | 50    | 40                                 | 75     | 100   | 100   | 100   | 8.75  |
| 2         | 15              | 17.5      | 11.0      | 6.5       | 0.0       | 0.0       | 50    | 30                                 | 65     | 91    | 100   | 100   | 8.56  |
| 3         | 10              | 17.5      | 9.5       | 13.0      | 0.0       | 0.0       | 50    | 20                                 | 55     | 81    | 100   | 100   | 8.36  |
| 4         | 5               | 17.5      | 7.5       | 17.5      | 2.5       | 0.0       | 50    | 10                                 | 45     | 69    | 96    | 100   | 8.10  |
| 5         | 0               | 17.5      | 6.5       | 21.0      | 5.0       | 0.0       | 50    | 0                                  | 35     | 58    | 91    | 100   | 7.84  |
| 6         | 0               | 12.5      | 5.5       | 24.5      | 5.0       | 2.5       | 50    | 0                                  | 25     | 53    | 87    | 96    | 7.61  |
| 7         | 0               | 7.5       | 5.0       | 27.5      | 5.0       | 5.0       | 50    | 0                                  | 15     | 38    | 81    | 92    | 7.26  |

TABLE NO. 4 (YIELD DATA FOR 1:3:5 MIX)

| Batch No. | Weight per Cu. Ft. Coarse Aggregate | Weight per Cu. Ft. Mixed Aggregate | F. M. of Coarse Aggregate | F. M. of Mixed Aggregate | Voids in Coarse Aggregate | Water-Cement Ratio | Slump in Inches | Bbls. of Cement per Cu. Yd. of Concrete (Taylor & Thompson Formula) | Bbls. of Cement per Cu. Yd. of Concrete (Exper.) |
|-----------|-------------------------------------|------------------------------------|---------------------------|--------------------------|---------------------------|--------------------|-----------------|---------------------------------------------------------------------|--------------------------------------------------|
| 1         | 81.0                                | 125                                | 8.75                      | 6.46                     | 0.481                     | 0.95               | 2.00            | 1.11                                                                | 1.10                                             |
| 2         | 85.0                                | 126                                | 8.56                      | 6.36                     | 0.455                     | 0.95               | 4.00            | 1.08                                                                | 1.08                                             |
| 3         | 86.5                                | 127                                | 8.36                      | 6.23                     | 0.445                     | 1.10               | 2.50            | 1.08                                                                | 1.07                                             |
| 4         | 88.5                                | 125                                | 8.10                      | 6.06                     | 0.433                     | 1.19               | 3.25            | 1.03                                                                | 1.05                                             |
| 5         | 88.5                                | 122                                | 7.84                      | 5.90                     | 0.433                     | 1.19               | 3.00            | 1.04                                                                | 1.05                                             |
| 6         | 90.5                                | 124                                | 7.61                      | 5.76                     | 0.420                     | 1.26               | 3.00            | 1.02                                                                | 1.04                                             |
| 7         | 91.0                                | 124                                | 7.26                      | 5.55                     | 0.417                     | 1.27               | 5.00            | 1.03                                                                | 1.04                                             |

TABLE NO. 5 (1:2:4 SERIES)  
Gradation of Coarse Aggregate

| Batch No. | Pounds of Stone |           |           |           |           |           | Total | Sieve Analysis—Per Cents Retained— |        |       |       |       | F. M. |
|-----------|-----------------|-----------|-----------|-----------|-----------|-----------|-------|------------------------------------|--------|-------|-------|-------|-------|
|           | Bin No. 1       | Bin No. 2 | Bin No. 3 | Bin No. 4 | Bin No. 5 | Bin No. 6 |       | 2-in.                              | 1½-in. | ¾-in. | ⅜-in. | 4-in. |       |
| 1         | 25.0            | 12.5      | 12.5      | 12.5      | 0.0       | 0.0       | 50    | 50                                 | 75     | 100   | 100   | 100   | 8.75  |
| 7         | 0.0             | 0.0       | 5.0       | 45.0      | 0.0       | 0.0       | 50    | 0                                  | 0      | 31    | 99    | 100   | 7.30  |
| 4         | 0.0             | 20.0      | 17.5      | 12.5      | 0.0       | 0.0       | 50    | 0                                  | 40     | 80    | 100   | 100   | 8.20  |
| 8         | 0.0             | 0.0       | 25.0      | 15.0      | 7.5       | 2.5       | 50    | 0                                  | 0      | 56    | 82    | 96    | 7.34  |
| 3         | 12.5            | 17.5      | 10.0      | 7.5       | 2.5       | 0.0       | 50    | 25                                 | 60     | 82    | 95    | 100   | 8.37  |
| 2         | 15.0            | 10.0      | 12.5      | 7.5       | 2.5       | 2.5       | 50    | 30                                 | 50     | 83    | 95    | 97    | 8.25  |
| 6         | 0.0             | 5.0       | 7.5       | 20.0      | 17.5      | 2.5       | 50    | 0                                  | 10     | 30    | 67    | 96    | 7.03  |
| 5         | 0.0             | 12.5      | 12.5      | 12.5      | 10.0      | 2.5       | 50    | 0                                  | 25     | 56    | 78    | 96    | 7.55  |

TABLE NO. 6 (YIELD DATA FOR 1:2:4 MIX)

| Batch No. | Weight per Cu. Ft. Coarse Aggregate | Weight per Cu. Ft. Mixed Aggregate | F. M. of Coarse Aggregate | F. M. of Mixed Aggregate | Voids in Coarse Aggregate | Water-Cement Ratio | Slump in Inches | Bbls. of Cement per Cu. Yd. of Concrete (Taylor & Thompson Formula) | Bbls. of Cement per Cu. Yd. of Concrete (Exper.) |
|-----------|-------------------------------------|------------------------------------|---------------------------|--------------------------|---------------------------|--------------------|-----------------|---------------------------------------------------------------------|--------------------------------------------------|
| 1         | 82.0                                | 125                                | 8.75                      | 6.73                     | 0.475                     | 0.70               | 2.50            | 1.44                                                                | 1.43                                             |
| 7         | 81.5                                | 118                                | 7.30                      | 5.76                     | 0.480                     | 0.75               | 3.00            | 1.43                                                                | 1.44                                             |
| 4         | 85.0                                | 124                                | 8.20                      | 6.37                     | 0.455                     | 0.78               | 2.50            | 1.41                                                                | 1.41                                             |
| 8         | 84.0                                | 122                                | 7.34                      | 5.81                     | 0.463                     | 0.78               | 3.00            | 1.41                                                                | 1.40                                             |
| 3         | 87.5                                | 123                                | 8.37                      | 6.48                     | 0.440                     | 0.75               | 5.00            | 1.40                                                                | 1.39                                             |
| 2         | 89.5                                | 124                                | 8.25                      | 6.39                     | 0.427                     | 0.74               | 2.50            | 1.37                                                                | 1.37                                             |
| 6         | 89.5                                | 118                                | 7.03                      | 5.59                     | 0.427                     | 0.89               | 2.75            | 1.35                                                                | 1.37                                             |
| 5         | 90.5                                | 121                                | 7.55                      | 5.93                     | 0.420                     | 0.82               | 5.00            | 1.34                                                                | 1.36                                             |

TABLE NO. 7 (1:2:3½ SERIES)  
Gradation of Coarse Aggregate

| Batch No. | Pounds of Stone |           |           |           |           |           | Total | Sieve Analysis—Per Cents Retained— |        |       |       |       | F. M. |
|-----------|-----------------|-----------|-----------|-----------|-----------|-----------|-------|------------------------------------|--------|-------|-------|-------|-------|
|           | Bin No. 1       | Bin No. 2 | Bin No. 3 | Bin No. 4 | Bin No. 5 | Bin No. 6 |       | 2-in.                              | 1½-in. | ¾-in. | ⅜-in. | 4-in. |       |
| 1         | 2.5             | 35.0      | 12.5      | 00.0      | 00.0      | 0.0       | 50    | 5                                  | 70     | 100   | 100   | 100   | 8.70  |
| 2         | 0.0             | 32.5      | 5.0       | 12.5      | 00.0      | 0.0       | 50    | 0                                  | 65     | 82    | 100   | 100   | 8.47  |
| 3         | 0.0             | 27.5      | 10.0      | 7.5       | 5.0       | 0.0       | 50    | 0                                  | 55     | 77    | 91    | 100   | 8.23  |
| 5         | 0.0             | 2.5       | 5.0       | 7.5       | 32.5      | 2.5       | 50    | 0                                  | 5      | 17    | 46    | 96    | 6.64  |
| 4         | 0.0             | 15.0      | 7.5       | 7.5       | 17.5      | 2.5       | 50    | 0                                  | 30     | 49    | 65    | 96    | 7.40  |
| 6         | 0.0             | 00.0      | 2.5       | 5.0       | 40.0      | 2.5       | 50    | 0                                  | 0      | 6     | 36    | 96    | 6.38  |

TABLE NO. 8 (YIELD DATA FOR 1:2:3½ MIX)

| Batch No. | Weight per Cu. Ft. Coarse Aggregate | Weight per Cu. Ft. Mixed Aggregate | F. M. of Coarse Aggregate | F. M. of Mixed Aggregate | Voids in Coarse Aggregate | Water-Cement Ratio | Slump in Inches | Bbls. of Cement per Cu. Yd. of Concrete (Taylor & Thompson Formula) | Bbls. of Cement per Cu. Yd. of Concrete (Exper.) |
|-----------|-------------------------------------|------------------------------------|---------------------------|--------------------------|---------------------------|--------------------|-----------------|---------------------------------------------------------------------|--------------------------------------------------|
| 1         | 82.2                                | 127                                | 8.70                      | 6.49                     | 0.475                     | 0.650              | 4.0             | 1.56                                                                | 1.52                                             |
| 2         | 86.6                                | 124                                | 8.47                      | 6.35                     | 0.445                     | 0.675              | 3.0             | 1.49                                                                | 1.49                                             |
| 3         | 87.5                                | 127                                | 8.23                      | 6.20                     | 0.440                     | 0.695              | 3.0             | 1.49                                                                | 1.48                                             |
| 5         | 88.4                                | 110                                | 6.64                      | 5.18                     | 0.435                     | 0.795              | 2.5             | 1.45                                                                | 1.47                                             |
| 4         | 93.3                                | 124                                | 7.40                      | 5.66                     | 0.403                     | 0.780              | 4.5             | 1.43                                                                | 1.43                                             |
| 6         | 84.7                                | 117                                | 6.38                      | 5.02                     | 0.458                     | 0.840              | 2.5             | 1.41                                                                | 1.50                                             |

TABLE NO. 9 (1:1¼:3½ SERIES)  
Gradation of Coarse Aggregate

| Batch No. | Pounds of Stone |           |           |           |           |           | Sieve Analysis—Per Cents Retained— |       |        |       |       |       | F. M. |
|-----------|-----------------|-----------|-----------|-----------|-----------|-----------|------------------------------------|-------|--------|-------|-------|-------|-------|
|           | Bin No. 1       | Bin No. 2 | Bin No. 3 | Bin No. 4 | Bin No. 5 | Bin No. 6 | Total                              | 2-in. | 1½-in. | ¾-in. | ½-in. | 4-in. |       |
| 1         | 2.5             | 27.5      | 7.5       | 12.5      | 0.0       | 0.0       | 50                                 | 5     | 60     | 79    | 100   | 100   | 8.39  |
| 2         | 0.0             | 2.5       | 30.0      | 17.5      | 0.0       | 0.0       | 50                                 | 0     | 5      | 92    | 100   | 100   | 7.97  |
| 4         | 0.0             | 2.5       | 17.5      | 20.0      | 7.5       | 2.5       | 50                                 | 0     | 5      | 48    | 83    | 97    | 7.33  |
| 3         | 12.5            | 12.5      | 17.5      | 20.0      | 7.5       | 2.5       | 50                                 | 0     | 25     | 57    | 87    | 96    | 7.65  |

TABLE NO. 10 (YIELD DATA FOR 1:1¼:3½ MIX)

| Batch No. | Weight per Cu. Ft. Coarse Aggregate | Weight per Cu. Ft. Mixed Aggregate | F. M. of Coarse Aggregate | F. M. of Mixed Aggregate | Voids in Coarse Aggregate | Water-Cement Ratio | Slump in Inches | Bbbs. of Cement per Cu. Yd. of Concrete (Taylor & Thompson Formula) | Bbbs. of Cement per Cu. Yd. of Concrete (Exper.) |
|-----------|-------------------------------------|------------------------------------|---------------------------|--------------------------|---------------------------|--------------------|-----------------|---------------------------------------------------------------------|--------------------------------------------------|
| 1         | 86.1                                | 121                                | 8.39                      | 6.50                     | 0.450                     | 0.65               | 2.5             | 1.58                                                                | 1.57                                             |
| 2         | 85.9                                | 120                                | 7.97                      | 6.22                     | 0.451                     | 0.67               | 3.0             | 1.53                                                                | 1.57                                             |
| 4         | 89.8                                | 121                                | 7.33                      | 5.80                     | 0.425                     | 0.69               | 3.0             | 1.56                                                                | 1.53                                             |
| 3         | 88.8                                | 123                                | 7.65                      | 6.00                     | 0.430                     | 0.67               | 3.0             | 1.55                                                                | 1.54                                             |

TABLE NO. 11 (1:1¼:3¾ SERIES)  
Gradation of Coarse Aggregate

| Batch No. | Pounds of Stone |           |           |           |           |           | Sieve Analysis—Per Cents Retained— |       |        |       |       |       | F. M. |
|-----------|-----------------|-----------|-----------|-----------|-----------|-----------|------------------------------------|-------|--------|-------|-------|-------|-------|
|           | Bin No. 1       | Bin No. 2 | Bin No. 3 | Bin No. 4 | Bin No. 5 | Bin No. 6 | Total                              | 2-in. | 1½-in. | ¾-in. | ½-in. | 4-in. |       |
| 1         | 30.0            | 7.5       | 12.5      | 0.0       | 0.0       | 0.0       | 50                                 | 60    | 75     | 100   | 100   | 100   | 8.75  |
| 2         | 2.5             | 27.5      | 7.5       | 12.5      | 0.0       | 0.0       | 50                                 | 5     | 60     | 79    | 100   | 100   | 8.39  |
| 4         | 0.0             | 17.5      | 12.5      | 12.5      | 5.0       | 2.5       | 50                                 | 0     | 35     | 65    | 87    | 96    | 7.83  |
| 5         | 0.0             | 0.0       | 2.5       | 27.5      | 17.5      | 2.5       | 50                                 | 0     | 15     | 68    | 96    | 100   | 7.79  |
| 3         | 20.0            | 10.0      | 5.0       | 7.5       | 5.0       | 2.5       | 50                                 | 40    | 60     | 70    | 88    | 97    | 8.15  |

TABLE NO. 12 (YIELD DATA FOR 1:1¼:3¾ MIX)

| Batch No. | Weight per Cu. Ft. Coarse Aggregate | Weight per Cu. Ft. Mixed Aggregate | F. M. of Coarse Aggregate | F. M. of Mixed Aggregate | Voids in Coarse Aggregate | Water-Cement Ratio | Slump in Inches | Bbbs. of Cement per Cu. Yd. of Concrete (Taylor & Thompson Formula) | Bbbs. of Cement per Cu. Yd. of Concrete (Exper.) |
|-----------|-------------------------------------|------------------------------------|---------------------------|--------------------------|---------------------------|--------------------|-----------------|---------------------------------------------------------------------|--------------------------------------------------|
| 1         | 84.4                                | 121                                | 8.75                      | 6.79                     | 0.460                     | 0.63               | 4.0             | 1.55                                                                | 1.53                                             |
| 2         | 85.3                                | 123                                | 8.39                      | 6.55                     | 0.454                     | 0.67               | 3.5             | 1.54                                                                | 1.52                                             |
| 4         | 89.6                                | 122                                | 7.83                      | 6.16                     | 0.428                     | 0.69               | 4.0             | 1.49                                                                | 1.48                                             |
| 5         | 89.0                                | 116                                | 7.79                      | 5.46                     | 0.430                     | 0.72               | 2.5             | 1.49                                                                | 1.49                                             |
| 3         | 92.1                                | 123                                | 8.15                      | 6.39                     | 0.410                     | 0.68               | 5.0             | 1.47                                                                | 1.47                                             |

TABLE NO. 13 (1:2½:4¾ SERIES)  
Gradation of Coarse Aggregate

| Batch No. | Pounds of Stone |           |           |           |           |           | Sieve Analysis—Per Cents Retained— |       |        |       |       |       | F. M. |
|-----------|-----------------|-----------|-----------|-----------|-----------|-----------|------------------------------------|-------|--------|-------|-------|-------|-------|
|           | Bin No. 1       | Bin No. 2 | Bin No. 3 | Bin No. 4 | Bin No. 5 | Bin No. 6 | Total                              | 2-in. | 1½-in. | ¾-in. | ½-in. | 4-in. |       |
| 1         | 30.0            | 7.5       | 12.5      | 00.0      | 0.0       | 0.0       | 50                                 | 60    | 75     | 100   | 100   | 100   | 8.75  |
| 2         | 2.5             | 27.5      | 7.5       | 12.5      | 0.0       | 0.0       | 50                                 | 5     | 60     | 79    | 100   | 100   | 8.39  |
| 4         | 00.0            | 17.5      | 12.5      | 12.5      | 5.0       | 2.5       | 50                                 | 0     | 35     | 65    | 87    | 96    | 7.83  |
| 5         | 00.0            | 00.0      | 2.5       | 27.5      | 17.5      | 2.5       | 50                                 | 0     | 15     | 68    | 96    | 100   | 7.79  |
| 3         | 20.0            | 10.0      | 5.0       | 7.5       | 5.0       | 2.5       | 50                                 | 40    | 60     | 70    | 88    | 97    | 8.15  |

TABLE NO. 14 (YIELD DATA FOR 1:2½:4¾ MIX)

| Batch No. | Weight per Cu. Ft. Coarse Aggregate | Weight per Cu. Ft. Mixed Aggregate | F. M. of Coarse Aggregate | F. M. of Mixed Aggregate | Voids in Coarse Aggregate | Water-Cement Ratio | Slump in Inches | Bbbs. of Cement per Cu. Yd. of Concrete (Taylor & Thompson Formula) | Bbbs. of Cement per Cu. Yd. of Concrete (Exper.) |
|-----------|-------------------------------------|------------------------------------|---------------------------|--------------------------|---------------------------|--------------------|-----------------|---------------------------------------------------------------------|--------------------------------------------------|
| 1         | 84.4                                | 121                                | 8.75                      | 6.66                     | 0.460                     | 0.74               | —               | 1.20                                                                | 1.19                                             |
| 2         | 85.3                                | 123                                | 8.39                      | 6.47                     | 0.454                     | 0.89               | 3.5             | 1.18                                                                | 1.18                                             |
| 4         | 89.6                                | 124                                | 7.83                      | 6.05                     | 0.428                     | 0.85               | 2.5             | 1.15                                                                | 1.16                                             |
| 5         | 89.0                                | 116                                | 7.79                      | 5.37                     | 0.430                     | 0.97               | 2.5             | 1.15                                                                | 1.16                                             |
| 3         | 92.1                                | —                                  | 8.15                      | 6.26                     | 0.410                     | 0.85               | 4.0             | 1.14                                                                | 1.14                                             |

TABLE NO. 15  
Summary of Data

| Mix     | Fineness Modulus |       | Cement per Cu. Yd. of Concrete |      | Voids in Coarse Aggregate |       |
|---------|------------------|-------|--------------------------------|------|---------------------------|-------|
|         | Max.             | Min.  | Max.                           | Min. | Max.                      | Min.  |
| 1:3:5   | 8.75             | 7.26  | 1.11                           | 1.02 | 0.481                     | 0.417 |
| 1:2:4   | 8.75             | 7.55  | 1.44                           | 1.34 | 0.475                     | 0.420 |
| 1:2:3½  | 8.70             | 6.38  | 1.56                           | 1.41 | 0.475                     | 0.458 |
| 1:1¼:3½ | 8.39             | 7.65* | 1.58                           | 1.55 | 0.450                     | 0.430 |
| 1:1¼:3¾ | 8.75             | 8.15* | 1.55                           | 1.47 | 0.460                     | 0.410 |
| 1:2½:4¾ | 8.75             | 8.15* | 1.20                           | 1.14 | 0.460                     | 0.410 |

\*F. M. Producing a minimum yield.

The results are shown graphically in Figures 1 and 2. In Figure 1, the curves indicate that the cement content increases rapidly for the higher fineness moduli. An upward turn appears in each of the curves at a fineness modulus of about 8.25. However, this condition is true only for the aggregates used in this experiment, since as is shown in Figure 2, the yield is governed by the voids in the coarse aggregate when the fine aggregate is kept constant.

Coarse aggregates can be produced which will have the same fineness modulus but will not have the same voids.

This is demonstrated in Table No. 6. The voids for Batch No. 7 are 0.480 for a fineness modulus of 7.30 and for Batch No. 5, the voids are 0.420 while the fineness modulus is 7.55. Referring to Table No. 5, it is noted that Batch No. 7 was poorly graded while Batch No. 5 was uniformly graded from coarse to fine. An examination of the tables will show several places where this condition exists. By selecting a series of well graded coarse aggregates, data for a set of curves could be obtained which when plotted would show an economical yield beyond the 3.25 shown in Figure 1. These curves fit only the conditions obtained in these tests. They are not general since the coarser stones are not well graded and were chosen to fit the extremes of the specifications.

### Cement Content

The curves of Figure 2 show the relation between the voids in the coarse aggregate and the cement content of concrete. All of the curves in this figure are practically parallel and there is no overlapping as in Figure 1. The equation of the curves is of the hyperbolic form but for practical purposes and especially within the range of these experiments, it may be assumed that the cement content of the concrete varies directly as the voids in the coarse aggregate when the fine aggregate is kept constant.

The cement content as found by means of Taylor and Thompson's formula and these tests agree very closely. This indicates that for all practical purposes the use of the formula is entirely justified. The formula can be used to very good advantage in the field since weights per cubic foot of the coarse and fine aggregates could be very readily determined and the average specific gravity of both materials is generally known.

The results of these tests do not agree with those given in Taylor and Thompson's Tables. There are two reasons for the variations. First, the values in their tables are based on sand weighing 89 pounds per cubic foot with 44 per cent voids based on 2.65 specific gravity of sand while the values shown in this table are based on the dry and rodded weight per cubic foot of the sand used or 111 pounds with 33 per cent voids based on 2.65 specific gravity of sand. Second, the values in their tables are based on constant voids in the stone while the values given in the tables of this paper are based on variable voids as determined from the dry and rodded weight per cubic foot of the coarse aggregate.

The writer wishes to acknowledge the assistance and suggestions given by Mr. A. D. Conrow, Engineer of Materials for the Kansas State Highway Commission, in the preparation of this paper.

### Large Concrete Spans on Reconstruction Work

The huge Kelvin Hall in Glasgow, which is famed throughout the United Kingdom, is now in course of reconstruction after the disastrous fire of 1925. The rebuilding work is well advanced and is attracting unusual attention because of two extraordinary features. Concrete roofs are being built and, to enable the work to be carried on, an extraordinarily complex scaffolding has been erected. So thick is the tangle of joists that the structure gives an impression of a tropical jungle. This complicated framework encloses a space of 12,000,000 cubic feet. The roof of the new building is planned in spans 110 feet wide. These are the widest concrete spans in the world, and they will be covered with slabs each having a surface area of 733 square feet, although only four inches thick.

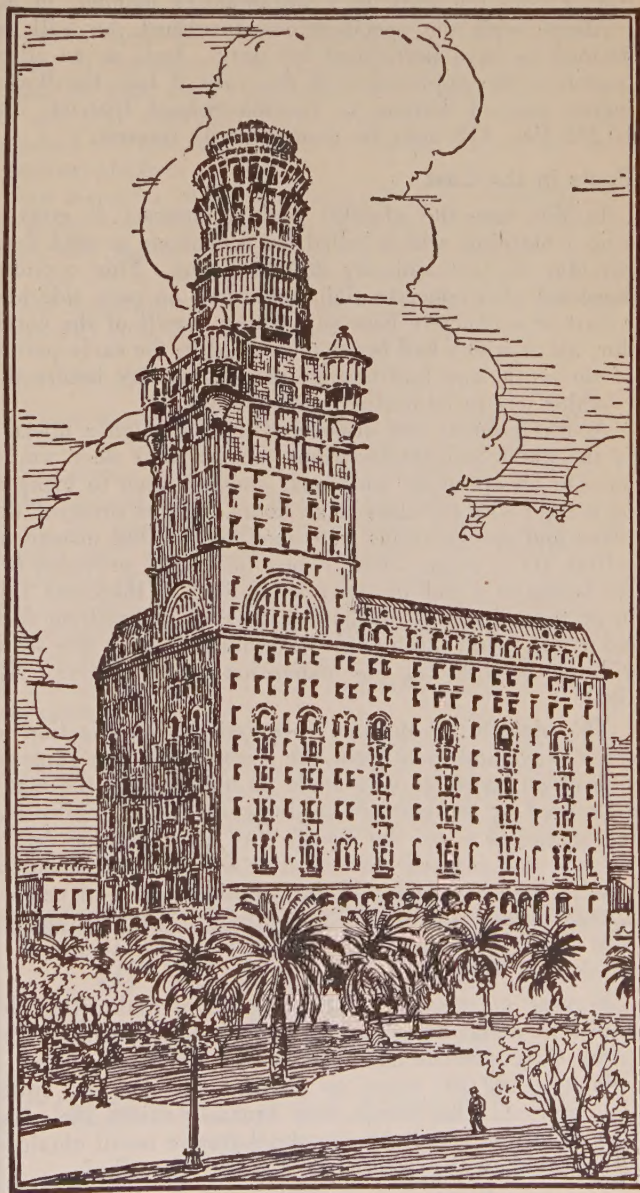
### South American City Boasts World's Tallest Concrete Building

In the city of Montevideo, in the south of Uruguay, South America, has been erected the tallest reinforced concrete building in the world, not excepting the Dallas, Texas, Medical Arts Building. The Palacio Salvo stands 331 feet above street level, exceeding by 85 feet the latter structure, which formerly held the height record.

The Palacio Salvo is a hotel, located on an important thoroughfare, the Avenida de Julio, and named for Lorenzo Salvo, a public spirited textile pioneer.

The entire building is cement-stuccoed. Almost 12,000 barrels of cement were required. It contains about 20,000 feet of floor space and has 450 rooms.

The architect of the structure is Mario Palanti. Lorenzo Gori is the engineer in charge. The contractors are Dyckerhoff & Widmann, Dr. Arnaldo Stoop being in charge of construction for that firm.



*The Palacio Salvo, a reinforced concrete building 331 feet high, has recently been completed in Montevideo, Uruguay. This is said to be the tallest reinforced concrete building in the world*

# Who Is Responsible for Defective Work?

## *Liability of Concrete Contractor for Damages Caused by Following Defective Specifications*

By LESLIE CHILDS

THE question of the liability of a concrete contractor for the unsatisfactory finish or result of work, caused by following defective plans and specifications, is one of several angles. And, since each case of this kind must necessarily be decided in the light of its particular facts, the subject cannot be covered by any hard and fast rule that would apply in all situations.

However, generally speaking, in the absence of a special guaranty, a contractor may not be held liable for a failure of result caused by following defective specifications furnished by an owner. In other words, if a contractor does the work in a workmanlike manner, in accordance with the specifications furnished, he will be deemed to have performed his duty. And, as an illustration of the application of this rule of law, the Washington case of *Larson v. Tacoma School District*, No. 10,255 Pac. 113, may be reviewed with interest.

### Facts in the Case

In this case the plaintiff took a contract to erect a school building, which called for a concrete ground floor corridor 12 feet wide by 250 feet long. This corridor consisted of a concrete slab, connected on each side and a part of a concrete base supporting a wall of the corridor, all of which had been constructed in the early period of the work, and had become thoroughly dry before the corridor was to be finished with topping.

At this point it was discovered that, through a mistake in the plans and specifications, the corridor floor would have to be raised an additional one-half inch to bring it on a level with the class room floors. In this situation the plans and specifications were modified so that instead of calling for a single filler of one inch, they provided for the laying of a slab of concrete one inch in thickness, this to be topped with a one-half inch layer of finishing with color mix. And the modified specifications for this work did not provide for any expansion joints therein. All right.

The plaintiff, it appears, followed the specification in every way, and completed the work under the supervision of an inspector who made no objection to the materials used or the manner of doing the work. Following the completion of the work, the floor became badly checked and cracked; the concrete fill upon the concrete base became loosened, and the colored topping of cement became loosened from the fill. In fact, from the report, it is clear that the result was very unsatisfactory in a number of ways.

Because of this, the defendant, school authorities, declined to make final settlement with the plaintiff. The latter thereupon brought the instant action to collect a balance of \$2,000 which he claimed was due him under the contract. This action then squarely raised the question as to who was liable for the defective result obtained in finishing off the corridor as has been described.

The defendant took the position that the failure of the top layers to adhere was because of poor workmanship. The plaintiff contended that the cracking of the cement

was due to the lack of expansion joints, which were not provided for in the specifications. And, the plaintiff argued that since he had strictly followed the specifications furnished, he should not be held liable for the result.

Upon the trial of the cause there was evidence on both sides of the question, and on this conflicting proof the trial court found in favor of the defendant. From judgment on this, the plaintiff appealed and the higher court in passing upon the record, in part, said:

### The Language of the Court

"There is no contention that the material used was not up to standard. \* \* \* The respondent's [defendant, school district] superintendent of school buildings \* \* \* was about the construction more or less, but it is not claimed that he was versed in concrete construction. The respondent had an inspector on the work at all times who was conversant with what was being done. \* \* \* Neither of them made any objection at all to the manner of doing the work or to the material that was used. \* \* \*

"There was no guaranty of results on the part of the builder in this case. The contract required the builder to 'furnish all labor, materials and supplies for and to build, erect, construct and complete the construction of said public school building, \* \* \* in accordance with the plans and specifications \* \* \* under the direction of the party of the second part (school district).'

"The result in building the corridor was disastrous, but the builder's right to recover is not to be defeated simply because the result contemplated by the school district has not been realized. He must be at fault, else recovery should be allowed. That the builder was not at fault in this case has been established by a preponderance of the evidence, in our opinion, \* \* \*

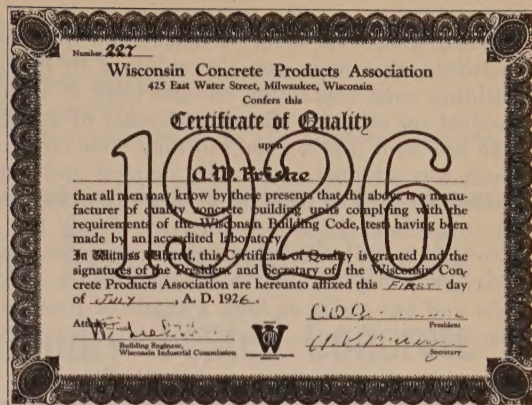
"The fault was in the defective modified plans and specifications furnished by the school district, for which the appellant was in no way responsible under any fair or reasonable construction of the contract. \* \* \* Reversed, with directions to the superior court to enter judgment for the appellant."

### Conclusion

The foregoing case was well reasoned by the court, and the holding announced appears to be in accord with the weight of authority on the question involved. This authority taking the position that, in the absence of a guaranty on the part of a contractor, he does not warrant the result obtained from following plans and specifications furnished by an owner.

In other words, in such a situation, the contractor cannot be held liable for a disappointing result, caused by following defective specifications, if he has performed the work in a workmanlike manner. In the light of which, the case reviewed becomes one of importance and value to concrete contractors in general, since it deals in a definite manner with this phase of a contractor's liability in performing contracts of this kind.

# How a Products Manufacturer Can TAKE ADVANTAGE of a Good Building Code



By "SPEC" COLLINS

OF late much has been written of Building Codes—good and bad. In fact, an epidemic of building coditis seems to have swept the country. Doubtless much of this attention to the revision of moss covered and antiquated codes and the drafting of 1928 models can be attributed to two sources—the splendid work of the U. S. Department of Commerce and that of the National Building Officials Conference. But this is not a treatise on building codes in general or an attempt to tell what they should contain—most building codes of today contain the things they should. On the contrary, it is an attempt to show the average concrete products manufacturer how he can take advantage of a good building code, provided his city has one—and a further endeavor to spur the manufacturer into securing a good building code, if his city does not have one.

## Code Must Be Enforced

The writer is a concrete block manufacturer who has had some experience with building codes, both from the promotional and sales standpoint. At the outset one statement must be made. A building code, no matter how carefully worded it may be, is worthless unless some provision is made for proper enforcement. In other words, *it must have teeth*. A properly enforced code is of priceless value to the reputable products manufacturer for it not only guards him against shoddy, unscrupulous manufacturers, but is an instrument of confidence in the builders in his community.

Everything hinges on this item of proper enforcement. And it is here that the products manufacturer can play a large part in making his code of value to himself. In the first place, he should make his own product of a high enough quality to comply with the code and enough higher to allow himself a safe margin if he has to deliver green products in order to complete some specific job falling under the code. Secondly, he should assist his

brother manufacturers in attaining this standard of quality and maintaining it. This can be done through personal contact or through his trade association. If his competitor maintains a high quality standard, he will find that it is much easier to get his product used in better-class and larger jobs than if the quality of products in his town varies with every man making concrete building units. If the competitor refuses to make a product that complies with code requirements, steps should be taken to see that unusually rigid inspection is made of his product and that it is put off the market as harmful to all concrete products.

An inspector who is enforcing the local Building Code covering concrete products deserves a boost from the reputable manufacturer every time it is possible to give it. His job is a thankless one and a few kind words and a few compliments on his vigilance spoken at the right time will spur him on to even better enforcement.

## The Evil Effects of Price Cutting

Three years ago in an Eastern city an overproduction of concrete block had led to a price war. Intent on meeting current prices on block, one manufacturer started to cheat on quality—the only way he knew to meet price. Soon he was followed by another and another until finally only one manufacturer in the city was making a creditable product. Now this man was hurt in two ways. Not only was he unable to sell his product because he was using clean aggregate and a reasonable amount of cement, but he found public confidence in all concrete products shattered because of the preponderance of poor blocks in the market.

It did not take him long to see that if the situation kept up, concrete block would command so little respect that competing materials would soon have all of his previous business and he would be forced to seek a new location for his plant.

Do Our BLOCKS Meet the Requirements  
of the

**State Building Code?**

They are Twice as Strong  
Absorb 1-3 the Water

**GOCHNAUER'S CONCRETE PRODUCTS**  
BEST by TEST

**UP TO A STANDARD  
NOT  
DOWN TO A PRICE**

**GOCHNAUER'S CONCRETE  
PRODUCTS**

Corner Meade and R. R. Tracks

Being a little broader visioned than his brother manufacturers, this man saw the solution to his problem—a building code containing enough teeth to insure a decent product on all jobs. Being somewhat of a politician, this man saw to it that a good building code covering concrete block was adopted by his city council and put into effect immediately. The code as written not only brought about its enforcement, but provided the funds for carrying it through as well. All this happened three years ago, yet today this town is one of the best block markets in the East and has easily as high a grade of products as any in that section of the country.

### State Tests of Our Concrete Building Block

Blocks selected by D. R. Collins of the Portland Cement Ass'n. on May 16th from that day's run to be tested at the age of 28 days. Tests made at Marquette Engineering Laboratories, Milwaukee.

Weight of blocks, average ..... 50 lbs.

Crushing load average ..... 103,000 lbs.  
(It took over 2,000 times the weight of the block to crush it)

Average crushing load, per square inch of area:

Net area ..... 1,287 pounds per sq. inch

Gross area ..... 918 pounds per sq. inch

(State requirements for public buildings only 700 pounds)

Percentage of absorption ..... 5.7%

(State allowance for public building.... 12%)

These tests are on file at our office and open to inspection. If this high type of building material appeals to you, let us estimate your building requirements.

### THE BADGER CONCRETE CO.

Concrete Block, Concrete Trim  
General Construction

191 MARION STREET

PHONE 2545

### The Selling Value of a Code

Now to get back to the real selling value of a code. Many manufacturers are unconsciously using it today and thinking little about it. Good codes contain a clause requiring certain tests on concrete block. As soon as this test required by the code is completed, the progressive manufacturer starts to cash in on it. If newspaper space is not too expensive he immediately advertises the results of his tests. Perhaps the use of a newspaper isn't practical, but direct mail is. In that case he graphically illustrates just what this test means and gets out a neat circular to the trade telling about it.

Perhaps one of the most widely used promotional stunts resulting from the building code is the Certificate of Quality issued by the Concrete Products Association. The certificate, handsomely embossed, is given members of this Association whose products have met a certain test. Hanging on the wall of an office, it always attracts attention. Reproduced in newspapers or as an illustration for direct mail advertising, it is sure to direct attention to the fact that the holder is a manufacturer of quality products. In Wisconsin, where a state building code is in effect, such a certificate is issued by the Wisconsin Concrete Products Association and countersigned by the State Building Engineer, who has charge of enforcement of the code. Following up this Certificate of Quality, members of the Wisconsin Association use a small guarantee of quality to send to owners of specific jobs. These promotional ideas, mind you, are based on a building code and its enforcement.

### Making the Most of Quality Tests

One manufacturer in a middle western city took the blocks selected for tests by the Building Inspector and had them placed on display in a prominent show window. The public was invited to guess the load each block could carry. When the tests were completed every person guessing was notified of the result and large advertisements in the local papers stated the outcome of the tests in no uncertain terms. That man has built a world of confidence in his product through intelligent use of his building code requirements. Another manufacturer carries as a by-line in all of his advertising—"Our blocks are tested and approved by the local Building Department."

### Mention Certificate in Specifications

Many manufacturers, when working with architects, carry their certificates of quality and test sheets with them. The certificate is an attention getter and the test sheets speak in the architects' own language. In talking to architects, other manufacturers insist that specifications state in no uncertain terms that concrete block or tile comply with all building code regulations. In one locality architects are specifying concrete block made "by a manufacturer holding a Certificate of Quality from the Concrete Products Association."

### Contractor Interested in Quality

The better class of contractors also seem interested in the building code requirements and how they are being met by the men from whom they buy concrete products.

## What L. B. Stands for

It stands for Luety Block and is stamped upon every concrete block we make. It is there for your protection. Every block that bears the L. B. stamp has more than measured up to every state building code requirement. Luety's Concrete Block has repeatedly been proven harder than rock in state tests. It's attractive in appearance and it's fire-proof. Use it when you build. Beloit Concrete Stone Company. Phone 558.

If they are provided with a copy of the block man's test sheet and a reproduction of his Certificate of Quality they can often convince the owner to use block where some other competitive material was originally intended. The reliable contractor is invariably a user of tested, high quality products. He has learned that they are not only easier and less expensive to lay, but that he is backed up by a certain sense of security when laying them.

### What Can Be Done with Building Code

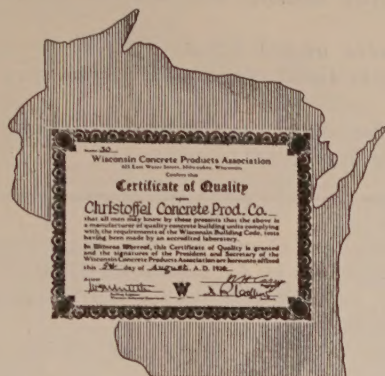
The tests required by a good building code seem to

make a greater impression on owners than any other class. The showing of a Certificate of Quality and a test sheet together with an explanation of how they were obtained, instill confidence in the owner.

### Promotion

Doubtless there are numerous products manufacturers who would employ these means of promoting and selling their products regardless of the existence of a building code. Yet the fact that such codes do exist and are being brought into force almost daily is giving reputable concrete products manufacturers fields to exploit their products.

Broadly considered, a properly enforced building code



## Backed by the State of Wisconsin

EVERY certificate of quality issued to members of the Wisconsin Concrete Products Association is signed by W. C. Muehlstein, Building Engineer, Wisconsin Industrial Commission.

Mr. Muehlstein's signature on this document signifies that the manufacturer to whom it is issued is producing concrete masonry building units that have met or exceeded the exacting requirements of the Wisconsin State Building Code.

When you purchase concrete masonry units from a manufacturer holding this certificate you are assured of getting high grade products bearing the approval of the Wisconsin Industrial Commission.

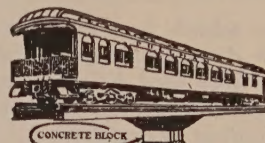


WISCONSIN CONCRETE PRODUCTS ASSOCIATION  
An Organization to Improve the Quality and Extend the Uses of Concrete Products  
425 East Water Street  
MILWAUKEE

if properly exploited by the concrete products manufacturer can be made to

1. Stabilize his market.
2. Stabilize quality.
3. Build public confidence in all concrete products.

## Why You Should Specify Economy Tested Concrete Blocks



EACH STANDARD CONCRETE BLOCK IS REQUIRED TO CARRY A WEIGHT GREATER THAN THAT OF A 60 TON PULLMAN

A recent test of our \*stock block made at Marquette University showed a compressive strength of 841 pounds to the square inch—141 pounds over the Wisconsin Industrial Commission Requirement.

This means that each block will support a weight of 168,200 pounds, or 84 tons,—20 tons more than the weight of a standard Pullman Car.

Absorption was only 5.10 per cent—Industrial Commission standards allow 12 per cent.

### THE WHY OF IT—

Economy Blocks are made from screened and washed gravel, the mix properly proportioned and the finished product carefully cured.

Look for the "E—" on our block. It is your protection against an inferior article.

## Economy Block Company

EIGHTH AND EAST NORTH AVENUE, WAUWATOSA

Telephone Bluemound 1620

\*Block for this test selected from stock by a representative of Wisconsin Concrete Products Association.

## Paris Building First Bridge of Reinforced Concrete

It is well known that the bridges over the Seine are an important part of the architecture of Paris, and the building of a new bridge is an event in which every good citizen feels a personal concern. As the Seine is much narrower than the Thames its bridges are far more numerous than those of London; within the old walls of the city the river is spanned in 25 places in a distance of about seven miles.

To facilitate river traffic an old bridge, the Pont de la Tournelle, which joined the Ile Saint-Louis to the south bank, has been demolished, and a new structure is being put in its place.

This new bridge will have a span of 75 yards and will be the first in Paris to be made of reinforced concrete, though it will have an outer covering of stone. It is being built in three parallel sections, two of which are now ready for their facing. The method of construction

is decidedly ingenious. The usual procedure is to make a wooden shell into which the concrete is poured. When the concrete has set the shell is removed in pieces. In this case, in order to save time and money, a single shell is being used for each of the three sections in turn. The problem is to move it from one to the other with the minimum of dismantling.

This has been accomplished by casting the arch in two halves (like the swinging bascules of the Tower Bridge in London, on a smaller scale), which are left divided in the middle. The concrete is given 20 days in which to set. Powerful jacks are then placed under the center of the arch, and the two sections, which have not yet been built into the embankments, are raised a few inches in the middle. Concrete is then poured into the gap between them; when it has set the jacks are removed and the wooden truss is withdrawn sideways and moved downstream into position for the next section.

The second section of the new Pont de la Tournelle has been treated in this way and the truss is now in position for the building of the third.

# Insuring Quality Concrete in Cold Weather\*

## Some Precautions for Protecting Concrete Against Injury During Cold Weather—Conditions Under Which These Protective Measures Should Be Applied

By F. H. McGRAW

Construction Manager, Dwight P. Robinson and Co., New York City

*Concrete which has alternately frozen and thawed while setting will not harden.*

*Concrete does not harden while frozen.*

*Concrete sets and hardens more rapidly at temperatures above 50 deg. F.*

*The minimum precaution permissible in cold weather is that which will safely protect the concrete against freezing.*

*Additional precautions to be taken and their extent depends upon the rate at which it is desired that the concrete attain its designed load-bearing strength.*

TO place concrete in cold weather, even to build large, important and expensive structures in the midst of the severe winters of our northern climate, is no longer a novelty. It is done every winter in every large city and in many small ones and little is said about it. But to make concrete of the highest quality, equal to that produced under the more favorable conditions of summer weather, requires care and a high degree of control over conditions, which control may not with safety be omitted, neglected or relaxed.

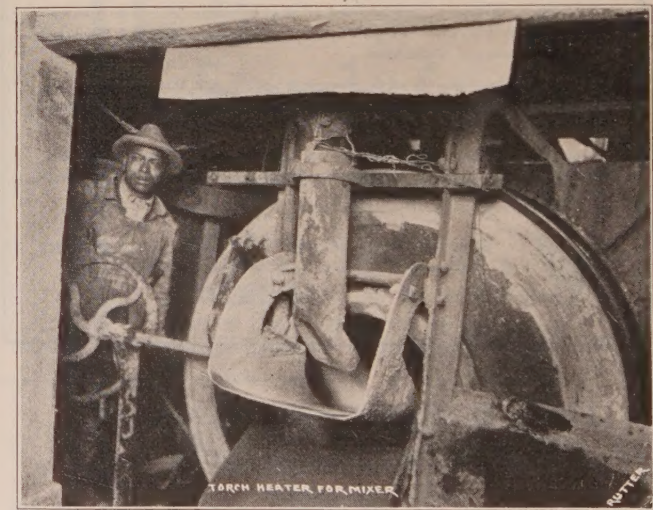
It is the purpose of this paper to outline the conditions which must be maintained to insure a quality product, rather than to deal with methods or apparatus or appliances used to secure and maintain these conditions. Before considering these essential conditions, it may be well to list a few well-established and generally accepted facts about the setting and hardening of concrete at low temperatures which have a direct bearing upon quality.

1. Concrete will develop its strength faster at higher

temperatures and slower at lower temperatures.

2. If concrete is to attain its designed load-bearing strength it must be kept above the freezing point of the water used in gaging.

3. If its designed load-bearing strength is to be attained in a reasonable period of time the temperature must be many degrees above the freezing point; 50 deg. F. is generally considered the point below which setting and hardening is greatly retarded.



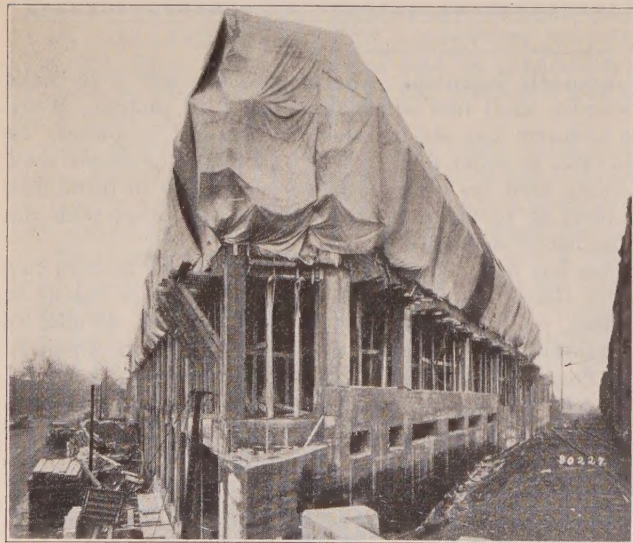
*A torch heater, used by Frost & Stone, New York contractors, to heat the materials in the mixer*

4. Concrete does not develop strength to any considerable degree while frozen.

5. To permit concrete to freeze means practically to suspend its hardening process during the period that it remains frozen.

6. To permit newly placed concrete to alternately freeze and thaw during the setting and hardening period will seriously reduce its ultimate strength.

In the light of these facts, it is not difficult to determine rather definitely not only the nature but the extent of the safeguards and precautions which must surround concrete at low temperatures. The only safe procedure is to take measures which will positively insure against freezing,



*A reinforced concrete building under construction in Detroit during January, 1927*

\*A paper presented at the Symposium on Field Control of Quality Concrete, A. S. T. M. Meeting, French Lick, Ind.

and if hardening at a normal rate is required to hasten construction progress or to strip forms in order to use them over again, the concrete should not be permitted to reach a temperature below 50 deg. F.

during its setting and hardening period. When the weather is moderate and a sudden or large drop in temperature is improbable, it is often considered safe to rely upon heating the aggregates and water before mixing. They should



□—❧—□

*Protecting the concrete during cold weather construction on the Comiskey Ball Park extension in Chicago*

□—❧—□

### The Two Essentials

The problem under consideration may, therefore, be divided into two parts: First, to prevent freezing of the concrete; and second, to maintain a temperature which will permit hardening to progress at an approximately normal rate. The first part of the problem may be accomplished by either of two methods or a combination of them: (a) to maintain the concrete above 32 deg. F., and (b) to lower the freezing point of the gaging water by adding a chemical compound to it. The use of the former method or a combination of the two is usually the safest course to pursue. The use of chemicals to lower the freezing point of concrete is effective over a limited range. The chemicals most commonly used to lower the freezing point of the gaging water are sodium chloride (common salt) and calcium chloride. Salt lowers the freezing point but it also slows up the hardening process. Calcium chloride lowers the freezing point to a greater extent than salt when used in equal quantity, but it accelerates the setting and hardening of the cement. A reduction of the freezing point by about 10 deg. F. is all that can be counted on by the use of calcium chloride without using such a quantity as would be injurious to the concrete. Should the temperature of the air drop below 22 deg. F., freezing would result unless heat were applied.

In climates where the thermometer is likely to drop below 22 deg. F., the safest course is to provide heat. Heat may be applied by two methods, either to the aggregates and water used in making the concrete or to the structure after placing. Whether both of these methods are to be used or only the former depends upon the minimum temperature to which the concrete is likely to be subjected

be raised to a temperature of 100 deg. F., but not above 150 deg. F., so that the resulting concrete may have a temperature of 80 deg. F. or more at the time of placing. Overheating of some types of aggregate should be avoided since they are liable to be injured at high temperatures. A number of effective devices are available for the purpose of heating materials.



*Quality concrete can be made and placed in cold weather if the precautions set forth in this article are followed*

### Heat Necessary to Harden Concrete

The chemical reactions which occur when cement sets and hardens produce heat. The result is a perceptible rise in the temperature of the concrete. When the mass

is large this heating effect offers considerable assistance in preventing freezing. If the temperatures were only a few degrees below freezing and could be counted upon to go no lower, the preheating of the concrete materials and proper covering of the placed concrete to retain the heat initially in the concrete, plus the heat generated during the setting period, would probably be sufficient to protect the work. If in addition there is dissolved in the mixing water from 2 to 4 pounds of calcium chloride for each bag of cement used, the work might be considered reasonably protected against freezing at a temperature of 20 deg. F. The phrase "reasonably protected" is used



*Heating aggregates by means of steam lines during cold weather construction in Charlestown, Mass.*

advisedly. In a high wind such concrete would freeze unless protected from it. But unfortunately our northern climate is not so dependable and other precautions are usually necessary for safety. Inclosing the structure and applying heat to maintain a temperature surrounding the concrete that is always above the freezing point regardless of the outside temperature is the one safe protection against freezing in northern climates in winter. If normal setting time of the concrete is the end sought then these same measures are used, but sufficient additional heat must be applied so that not only is the concrete kept above its freezing point but is maintained at a temperature above 50 deg. F. for at least two weeks, and preferably longer, after placing.

Many types of inclosure that have been devised for retaining heat within and around concrete structures have been described and illustrated in articles in the technical press and in the literature of concrete construction. It is not within the scope of this paper to deal with them. Suffice it to say that since their primary purpose is to safeguard the quality of the concrete in the structure by maintaining favorable temperature conditions, it is of first importance that such inclosures should be designed and constructed with such thoroughness and care as will insure their performance of this function.

### Winter Curing

It is also important in such cases to insure against the too rapid drying of the concrete. The heat used to maintain the higher temperature not only quickens the setting but also accelerates drying, especially since the cold outside air is often of low relative humidity. When cold air, even of high humidity, is heated its relative humidity is greatly reduced. This warmed air, of low humidity, has a marked effect on the drying out of exposed concrete. Sprinkling should be practiced, in such cases, for a week or more after placing.

In conclusion, "quality" concrete, and permanent concrete, can be placed in cold weather if well-known and generally recognized precautions surround it and intelligent supervision and control are mixed into it. Quality concrete in winter or summer is not a mixture of cement, sand, stone and water, but requires a fifth component—intelligent supervision.

### Celluloid Model of Experimental Dam Prepared

A celluloid model of the Stevenson Creek arch dam built near Fresno, Calif., under the supervision of the Committee on Arch Dam Investigation of the Engineering Foundation, has been contrived by Prof. George E. Beggs of Princeton University, assisted by D. B. Sloan, a graduate student of the Princeton Engineering School.

The Engineering Foundation could not afford to build and test more than one full-size dam since the expense would approximate \$100,000 for each such undertaking. Yet the information needed cannot be obtained from one specimen. It was this situation that brought about the construction of the celluloid model at Princeton, and the planning of other models. Prof. Beggs has used celluloid successfully in models of concrete arch bridges and other engineering works.

After measuring the bending (or deflection) and the stretching and compression (strains) caused by the water held back by the dam in the reservoir, in the celluloid model where mercury instead of water against the dam was used, Prof. Beggs discovered that there was a remarkably close agreement between his tests and computations and the accurate measurements made on the dam itself.

From this one set of tests the foundation concluded that further study would show that it would be sufficient to make a celluloid model of a proposed dam, and test it very carefully with precise instruments instead of building a large model of concrete at much greater expense.

### Southwest Road Show and School Program in Formation

A partial program of the third annual Southwest Road Show and School has been made available by the Wichita Thresher & Tractor Club of Wichita, Kansas. The show and school are to be held under the auspices of the club, at the Exposition Building, Wichita, on February 21, 22, 23 and 24.

Equipment, highway location and traffic, traffic studies and highway finance, design and construction, maintenance, and road-building materials are to be included in the demonstrations. Motion pictures of several of these will be shown before each program.

The Bureau of Public Roads, the State Highway Department and the Engineering Department of the Kansas State Agricultural College are co-operating.

# EDITORIALS

## *How We Get Rich*

**I**N these days of strenuous competition, especially between industries, it is interesting to note that someone has found out some definite reasons for the rapid increase of wealth in this country. That is, it is interesting if we can apply the whys and wherefores to our own business.

A Dr. Godfrey from Boston appeared before the annual meeting of the Associated Business Papers late in October and reported the results of a 21-year investigation that he and his associates have made, into the reasons for increase of wealth. With a competent staff digging into the records since 1880, he has produced charts proving that wealth, measured in terms of usable materials and services, has increased almost exactly in proportion to the growth of the non-fiction printed page.

Up to 1840 the wealth increase was only in proportion to the population increase; after 1840, with the advent of textbooks and a few trade journals, the curve of wealth started going up. The curve since 1900 is more than 45 degrees and follows (not precedes) almost exactly, the remarkable increase in general education and technical books and publications.

The story is a long one and will soon be published in book form, but the lessons from the preliminary report can be especially applied to the comparatively young and rapidly developing industries, of which the making of concrete is manifestly one.

We have all had a hazy idea, with occasional individual proofs, that education in industry pays. And now that actual proof is at hand, it behooves the leaders in the concrete construction industry, and those who aspire to leadership, to utilize the printed pages of their textbooks, their association bulletins and their business journals, to carry the invasion of good concrete construction into fields that have heretofore only been partially covered or hardly touched.

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## *Profits*

**T**HE concrete products industry is not an industry apart. It is subject to the same trials and successes as all other industries. Business developments and trends that affect other manufacturers are also vital to the concrete products manufacturer.

Wherever men gather to talk over the welfare of their business, certain conclusions are reached and these conclusions apply to the concrete products industry as if they were derived from a study of its problems. They all have the irresponsible competitor and price cutter; they all have a merchandising prob-

lem; they all realize that this is a period of large volume production and small unit profits; they all know that their salvation lies in co-operative efforts to meet these conditions.

A story on another page of this issue describes the methods used by the Hammond Concrete Products Works to meet this situation. The selection of only a few standard units for manufacture, turning these out in large volume in a plant designed to produce them at the lowest cost, then selling the units at a small profit for each unit, and operating the plant at its maximum capacity so as to reduce overhead—these are the methods that will prove the salvation of the products manufacturer.

It is estimated that the concrete block manufacturing equipment in one fairly large city has an aggregate capacity for turning out 35,000,000 block per year. Last year the sales of concrete block in that city totaled only 5,000,000! Overhead, equipment and plant expenses are seven times as great as they should be.

Naturally, the products manufacturer operating his plant at only one seventh capacity must earn a relatively large profit on each unit to make out. But if the plant operated at full capacity, his aggregate profits would be much greater even if his unit were very greatly reduced.

Following the trend of business by increasing his volume, thereby reducing costs and making it possible to sell at a lower price, expands the potential market, opens up new markets and increases sales. It also helps to eliminate the irresponsible competitor who, with his limited capacity, cannot "stand the gaff."

Such, unmistakably, is the present trend in the concrete products industry. The foresighted manufacturer will fit his efforts into the scheme of things and reap his reward.

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## *Beauty in Concrete*

**E**VERYWHERE beauty is becoming recognized as a factor in business progress. That product which is beautiful as well as useful has a tremendous trade advantage.

People have learned that beauty and efficiency go hand in hand—that the beautiful structure is one in which the materials used are treated in the most logical manner.

The strides made in the uses of reinforced concrete and in concrete masonry units in buildings of all kinds, indicate the possibilities in architectural uses of concrete. One architectural magazine devoted an entire issue to the uses of concrete.

# Here and There

## Some Random Notes on Visits with Concretors in the Field

**L**OCAL concrete products associations in a number of localities are doing much to put over concrete building units in their communities. For instance, in one large city where a price war is threatened, the foresighted manufacturers are looking the situation squarely in the face and wondering what can be done. Unfortunately, when a price war rages there is also a great danger of a let-down in quality. That would be bad for the products industry for many years to come and should be prevented.

In that city they do not now submit block for test in the city building inspector's office. So the solid block manufacturers got together, persuaded the city to get a testing machine and to enforce the building codes. In that way quality, at least, will be maintained, war or no war. And the irresponsible manufacturer who is cutting prices will watch his step if he is compelled to turn out a quality product or get his block thrown off the job.

Such a step may not prevent a price war, but it will at least keep up the good name of concrete building units. Also, it is not so easy to cut prices when quality must be maintained.

**I**N Finland, the land of ice and snow, they have found a way to use the ice and snow in making a light-weight, porous concrete. Evidently they believe in capitalizing their local resources.

They call the product "ice concrete." It is made of cement and sand, like other concrete, but it differs from ordinary concrete in that it is made extremely porous by mixing it with crushed ice and snow. The ice is then melted by heating the mixture and this honeycombs the concrete. They say they can use from 50 to 80 per cent of ice or snow in the mixture.

If this method spreads, it will be necessary to develop an ice-cement ratio. The information is being passed on to you as a cold-weather suggestion!

**H**ERE is another peculiar thing. In Iola, Kansas, a dollar watch (the make was not mentioned) which had been embedded in solid concrete for twelve years, was discovered by a workman on a concrete bridge gang. The watch was exposed when the old concrete abutment was destroyed. It began ticking as soon as it was wound.

**"M**ILCRETE Masonry" is the title of a little leaflet that is being distributed monthly by the Milwaukee Concrete Products Co-operative Association. Its object, says the announcement in the first issue, "is to tell the world of the virtues of concrete block." Not a bad idea, because the world still needs a lot of information on concrete block.

**I**T is interesting to go back over the trail we covered last year and see what has been going on in the plants since then. We did that recently and had some pleasant surprises.

Here was one products manufacturer who had taken on Haydite since we saw him last. His business is rushing and his light-weight block are in great demand.

**L**AST YEAR there was a concretor who had started in making a few pipe for culverts. He thought maybe that if that line went good he'd branch out a little. When the same plant was visited this year, the yard was plumb full of concrete pipe of all sizes and the pipe business was going full blast. He had hit upon a new line that expanded his business.

**I**N the office of a very progressive concrete products manufacturer we saw an array of magazines on a bookshelf. Every magazine in the concrete construction field was there and they looked as though they had been handled, too. Then there were some other magazines in his competitor's field, and they looked as if they had been read.

"Sure," he said, "I get a lot of tips from the magazines in my competitor's fields. Often they have some dandy merchandising suggestions and anyway I want to know what is going on in those fields and what the fellows that compete with me are thinking about."

People in other fields often have ideas that will work out wonderfully well in our field, too. You can get a lot of good suggestions from any industry.

**S**PEAKING of "back yard" competition in the concrete block game, a concrete products manufacturer said the other day, "Did it ever occur to you that the concrete block game is a good deal like farming? If a fellow has tried everything else and failed, he generally goes to farming and makes a worse mess of it than of any other thing he has ever done. Many of the men in the block game that I have run into remind me a good deal of that kind of a farmer."

**T**HERE is a "fringe market" for concrete products that can be yours by aggressive selling. It is that market where the buyer is undecided or indifferent as to which material he chooses and he will be swayed one way or the other by educational propaganda or by good salesmanship.

# Tornado Again Tests Present-Day Construction

**St. Louis Disaster Emphasizes Lessons Taught in Miami and Havana—Unit Masonry Structures Must Be Reinforced—No Damage to Reinforced Concrete Structures—No Concrete Block Structures in St. Louis—Performance of Concrete Masonry Structures on Illinois Side of the River—Some Conclusions**

A FEW minutes after one o'clock in the afternoon of September 29, St. Louis was swept by a tornado that was almost equal in violence to the historic twister that struck the same city on May 27, 1896. The storm struck first in the region south of Forest Park. It continued in a northeasterly direction toward the Mississippi River, crossed to the Illinois side of the river at the McKinley Bridge, swept through Venice and Madison and well into Granite City before its fury was spent.

The width of the strip affected by the storm varies from 1,000 to 1,500 yards, with an average not far from 1,200 yards on the St. Louis side of the river. The total damaged area within the city contains about 4½ square miles.

The property damage is estimated roughly at \$50,000,000, while the loss of life totaled eighty-one in St. Louis and eight on the Illinois side.

The tornado passed to the north of the downtown business section of St. Louis, so that only a few modern skeleton-framed buildings were put to the test. These few had structural frames of reinforced concrete and all came through the storm without damage. The greater part of the affected zone comprises a close-in area that is in the transition period from formerly high-class individual dwelling houses to apartment houses, mingled with various uptown business sections. Toward the river the tornado's path included a number of factory buildings, but the greater part of the region was occupied by large dwellings now used as rooming and boarding houses and by moderate-size apartment houses and business buildings of two and three stories. A part of this old residential section is now occupied by a negro population.

## Unit Masonry Structures Must Be Reinforced

Aside from a few structures of reinforced concrete, all buildings in the tornado zone were of brick bearing wall construction or of wood frame construction, the former predominating. St. Louis is in the midst of an area that produces clay brick and for a long time this material has been the one most commonly used. This storm has consequently furnished an opportunity for the study of average clay brick masonry subjected to severe lateral forces in a region where it was the prevailing type. The failure of this masonry to stand up under the test gives powerful support to the belief that no unit masonry construction is safe unless it is reinforced in some effective manner.

Brick buildings were damaged in quite a uniform manner in any one vicinity. Tornadoes have a freakish habit of destroying one building and leaving another one unharmed next to it. In this case there was little of a freakish nature about it. Block after block of 2-story brick buildings had the roof and upper story walls demolished while the first story walls remained in place; but almost invariably the entire interior was demolished by falling materials. The destruction of the roof and upper story walls was in fact quite a characteristic

form of clay brick failure, in 3-story buildings as well as 2-story.

Another common type of brick failure consisted of the breaking away of an exterior wall from parapet to grade, leaving the rooms exposed to the open air. This form of failure occurred more especially in school buildings and apartment houses. At the Columbia and Riddick grade schools, where failures of this kind occurred, peo-

*Four conclusions of far-reaching importance to the construction industry were again forcibly brought to the front in the recent St. Louis tornado, as they were in the Miami and Havana disasters. They are:*

- 1. The reinforced concrete frame provides the greatest possible security against storm damage.*
- 2. Ordinary masonry wall construction is not safe unless the wall is reinforced and tied in some manner.*
- 3. A first floor of reinforced concrete in dwelling houses provides a secure storm cellar.*
- 4. Buildings should be anchored to their foundations. Roofs and floors should be anchored to the walls.*



*Leonardo Hotel-Apartments on Lindell Blvd. This is a 9-story reinforced concrete building faced with brick and located in the center of the affected zone. No damage resulted except broken windows*



*Shriners' Hospital for Children, on Kingshighway. This brick bearing wall building was unroofed, but with little damage to masonry. In the background is the Washington University School of Medicine*



*The Windsor Hotel, on Lindell Blvd. This is also a reinforced concrete building, faced with brick. It is located in the center of the affected zone but suffered no damage except broken windows*



*Wrecked brick buildings in the 4100 block in Olive Street. Not one escaped damage*



*South wing of the St. Louis University High School. Smashed windows in this wing constitute the only damage. Floors and structural frame are of reinforced concrete*



*Columbia School. This was a three-story brick bearing wall building with wooden floors. It has been condemned for further use until reconstructed and it may be torn down*

ple in the streets saw the terrifying spectacle of school children seated at their desks for a few seconds after the walls had fallen away. Providence had in each instance left the floors intact and the children soon found safety in the corridors.

Stone buildings withstood the storm in much better fashion than brick buildings. It is believed that the larger size of the individual stone units had much to do with this better performance. It should be remembered also that, in general, a higher quality of mortar is used in laying stone masonry than in laying brickwork.

Wood frame buildings, single dwellings for the most part, failed in less uniform fashion than buildings of clay brick. Many wooden buildings were demolished beyond recognition, others were racked out of shape, while still others lost roofs and porches without being damaged by racking. As in other violent storms, the light weight of wood frame buildings permitted the wind to toy with them.

#### No Damage to Reinforced Concrete Structures

Buildings of reinforced concrete performed in the usually good manner. Only five structures of this type were found in the storm area but none suffered damage aside from broken windows. Four of these structures include the 7-story Windsor Apartment Hotel, 4209 Lindell Boulevard; the 9-story Leonardo Apartments, at 4166 Lindell



*The Roselle Hotel, on Lindell Blvd. This was a three-story building having brick bearing walls and wooden floors. The roof, the upper story walls and the entire interior are completely wrecked*

Boulevard; the Washington University School of Medicine, in South Kingshighway; and St. Louis University High School, 4970 Oakland Avenue. These buildings stand unharmed in the midst of general damage and destruction. It is of great significance that in none of them had any of the brick facing or stone trim broken away. This means beyond doubt that the rigidity of the reinforced concrete structural frame prevented swaying or vibration, which, had it occurred, would have broken the facing materials away from the structural concrete.

The fifth reinforced concrete structure is the coaling station of the St. Louis Terminal Ry., in Venice, on the Illinois side. The asbestos roofing was ripped off, but no structural damage occurred.

#### Concrete Block Structures

No concrete block masonry was found in the tornado zone in St. Louis, so that no large-scale comparison with clay brick masonry is possible. There are some concrete block buildings in certain sections of St. Louis, but the building code of the city contains no regulations covering



*A row of brick apartments at the southwest corner of Maryland Avenue and Whittier Street. The front wall was torn clear of the rest of the building*

concrete masonry units and the present city building department refuses permits for that material.

On the Illinois side of the river some concrete block buildings were found, and in spite of the inferior design and workmanship that went into them they performed fully as well as other types of masonry. Several concrete block buildings fell and others in the immediate vicinity were unharmed. The Schaefer Garage, in Madison, Illinois; the Venice Garage, in Venice, Illinois; and the Miller Garage, in the same town, all collapsed. The exterior walls in each building were of concrete block, only 8 inches thick, without pilasters and without any other form of lateral or cross-bracing, and without anchorage between walls and roof. With such construction nothing but failure can be expected. On the other hand, some concrete block buildings near the collapsed garages, of similar construction, were not damaged.

#### Industrial Buildings

A number of factory buildings in the storm area suffered in varying degrees ranging from serious damage to complete collapse. These buildings, without exception, had exterior bearing walls of clay brick and interior construction of wood supported on wooden posts. Perhaps the most complete failure in the entire storm area is that of the Novelty Shoe Co. factory at the corner of Leffingwell Avenue and Benton Street. This 3-story brick building



*A one-story concrete block garage, 51 by 101 feet, at Madison, Illinois. Shown standing are the office and living quarters, unaffected except that the roof was blown off, and as shown, has already been replaced. Walls of this building were 8 inches thick, of cinder block and 9 feet high, without pilasters or other form of bracing. The wooden roof was not anchored to the wall. Interior supports consisted of two rows of 4- by 6-inch wooden posts, 6 posts to the row*

was completely leveled. Until a month before the storm when the factory was shut down, a thousand men were employed in it. The shut-down prevented what otherwise would have been a frightful loss of life.

A feature of the storm which has caused much serious thinking was the extensive damage or partial destruction of nearly every school building of the bearing-wall type located in the tornado area. It is estimated that 6,500



*A wood frame residence at Madison, Illinois. The building was not anchored to the foundation wall and was blown off the wall and now rests partly in the basement. The foundation wall is of concrete 8 inches thick up to grade, with 5 courses of concrete block from grade to floor sill. Had the building been anchored, it would probably not have been affected*

school children were in the ten damaged schools at the time of the storm. It is considered a miracle that only eight pupils were killed. Comparisons are being drawn between these ten shattered school buildings of the bearing-wall type and the two school buildings of reinforced concrete skeleton construction which stand unharmed. The latter two buildings are the St. Louis University High School and the Washington University School of Medicine, both splendid examples of the reinforced concrete structural frame with brick facing. Churches and hospitals of the bearing-wall type fared no better than schools.

Several conclusions of a rather positive character may be drawn from the action of buildings in this tornado. First of all, it has again been demonstrated that the reinforced concrete structural frame provides the greatest possible security against storm damage. Results of other storms would justify similar recognition of the concrete-encased steel frame.

A second conclusion, also based on the results of other violent storms as well as this one, is that ordinary masonry wall construction is not safe unless the wall is reinforced and tied in some effective manner.

Third, the St. Louis tornado has again brought home the conviction that a first floor of reinforced concrete in dwelling houses would provide a secure storm cellar in time of emergency.

The fourth conclusion is that buildings should be anchored to their foundations and roofs, and floors should be anchored to walls. Many buildings in St. Louis received their worst damage from being blown off their foundation walls. Had the superstructures been properly anchored the damage in many instances would have been much less than it actually was. This fundamental principle of good construction should require no demonstration, but it is in fact very often disregarded.

#### A Method of Reinforcing Masonry Walls

Regarding the second of the foregoing conclusions, attention is invited to an effective method of reinforcing masonry walls which has for some years been in vogue in southern California and lately the method has been made a requirement in several building codes of cities in Florida. The masonry reinforcement consists essentially of a light reinforced concrete frame built as an integral part of the wall. Very little form work is required. Reinforced concrete girts are concreted in place at each floor level and at the top of the wall. The girt is the full width of the wall and is continuous around the building. The vertical members of the frame are made by leaving spaces in the masonry at intervals of five to eight feet, in which reinforced concrete columns, or posts, are concreted after the masonry is laid up. Posts are connected to foundation walls by dowels set in place when the foundation wall is built. In this method the reinforced concrete structural frame utilized in the construction of large buildings is adapted to the needs of a small building. The main point of difference is that whereas in a large building the structural frame is figured to carry the entire load, this frame for a small building is intended primarily as a means of adding to the strength and stability of the masonry-bearing wall. The concrete frame confines the masonry and forces the wall to act as a monolithic unit, besides serving as a tie around the building. It prevents the breaking away of that first brick or block that starts the trouble. If masonry construction is to be made secure against disaster, this method or some equally effective method of reinforcement must become the general practice rather than the exception.

# A Profit in 14-Cent Block!

Six Men, Distributed as Follows, Make 3200 Block Per Day:

3—Operators, one for each of the 3 machines

1—Mixer Operator, who proportions and mixes all the concrete required

1—Truck man, who transports the racks from all the machines to the yard

1—Laborer, who unloads the racks and piles the block

6—Total

A STRIKING example of the economies that can be brought about in concrete block manufacture by efficient plant layout is found in the plant of the Hammond Concrete Block Works at Hammond, Indiana.

Here Jake Golden, who has succeeded his father as head of the "Works," makes 3200 block per 9-hour day with a force of only 6 men. This means an average of 533 block per man per day! Products manufacturers usually consider 300 blocks per man per day a fair average; 400 block per man is good; 500 is very exceptional, and 533—!

He figures the cost of his 8 x 8 x 16 plain block at 8 cents in the yard, adds 2 cents per block for delivery cost, and makes a profit of 4 cents per block on a 14 cents sales price.

## Cut Down Varieties of Block Made

Several items are responsible for the large volume of production per man, but the arrangement of the equipment and the methods adopted are the principal causes.

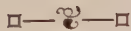
In the first place, an effort is made to eliminate the manufacture of a large variety of blocks. As nearly as possible, the plant will standardize on the 8 x 8 x 16

plain block and on the small tile. At the present time it is necessary to make some face block to supply the demand, but the "Works" is planning to discontinue this line entirely if an arrangement can be made with another local manufacturer for supplying the face block.

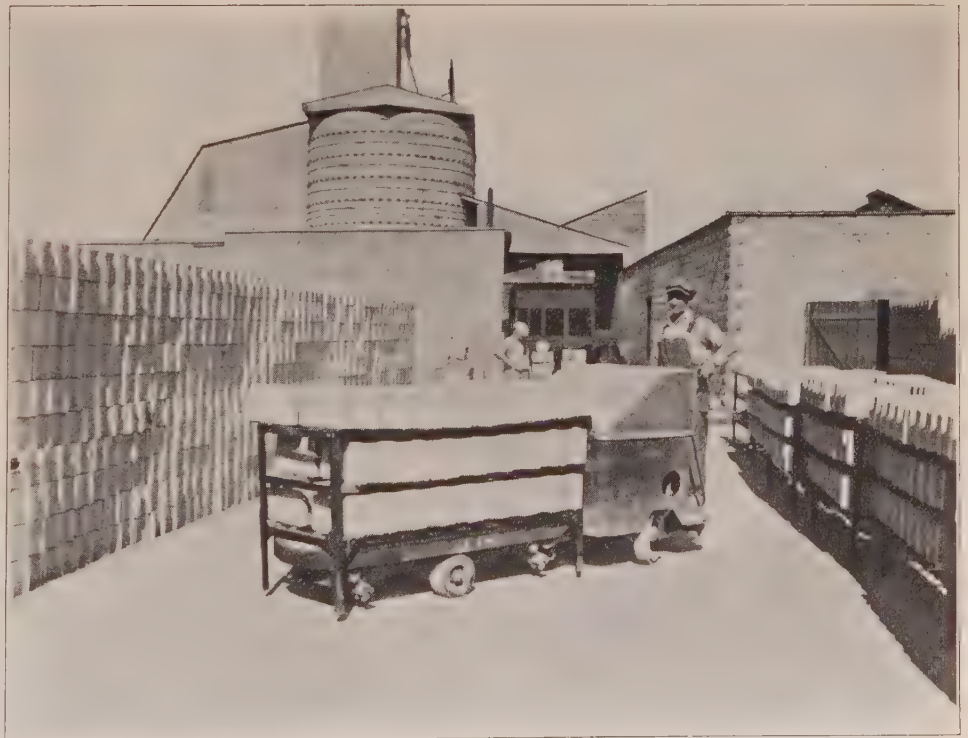
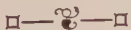
Large volume production of only a very few kinds of product and volume sales at a low unit profit is the aim. In this regard, the "Works" are simply following the trend in all other manufacturing industries. Such a policy will also be effective in eliminating the small back-yard block man who is the thorn-in-the-side of many a concrete products manufacturer.

## The Market for Block

The total present sales of concrete block within the trade area of the Hammond Concrete Block Works is now about 500,000 plain block and 250,000 face block. There are now 6 concrete block manufacturers in Hammond alone and 4 other manufacturers in nearby cities also consider Hammond their proper sales territory. The result, as in many other locations where similar conditions exist, is a price war that will probably result in the survival of the fittest. The man who can make and sell block in



*One man, operating a gasoline-powered truck lift, handles all the block from the machines to the yard where another man stacks them*



volume and depend for his total profit on an aggregate of small unit profits has an advantage over the man who must have a larger profit per unit to make out.

### The Plant Development

The Hammond Concrete Block Works was started back in 1904 by the father of Jake Golden, who now operates the plant. The first plant was so located that all the materials had to be hauled in with wagons. The first move was to locate the plant on a railroad siding. As the business grew, another small block manufacturer was bought out and the plant was moved to its present location. At that time there was only one shed, which constituted the entire plant.

Little by little, as the business grew, the buildings were enlarged and new structures were built, always according to a definite idea which represented the completed plant. The work of extending and enlarging the plant was always done with the plant force during the slack time of the year.

### Present Plant

The present plant consists of two large concrete block buildings on either side of a railroad spur track. In one of the buildings are two Universal power block machines, while the other building houses a Blystone hydraulic block machine and hand machines for making chimney block and other specials. In this building there are also two concrete stave silos for aggregate storage as well as the mixing and proportioning equipment.

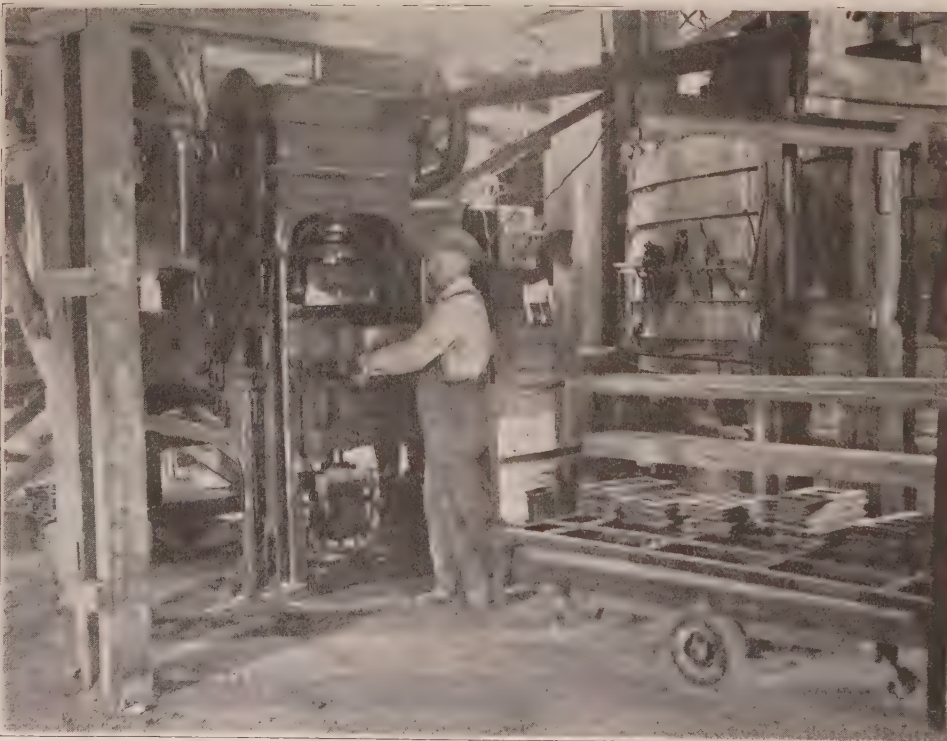
The operation of the Blystone hydraulic block machine has excited considerable interest. It was installed about April 1, 1927, primarily for experimental purposes.

Jake Golden considers the machine very satisfactory from every standpoint. It will produce 4 block or 8 tile per minute with one man who acts as off-bearer, taking the block from the machine and placing them on the racks. The machine is entirely automatic, feeding its own pallets from a stack placed in guides at the back of the machine.



*Materials are received in bottom-dump cars on a sidetrack that passes between the two plant buildings. A track pit supplies either the silos or the mixer bins*

The aggregate used for block and tile are limestone screenings, which are received in bottom dump cars on the siding between the buildings. The cars dump into a track hopper from which the screenings are elevated with a bucket elevator into two Blaw-Knox steel overhead bins.



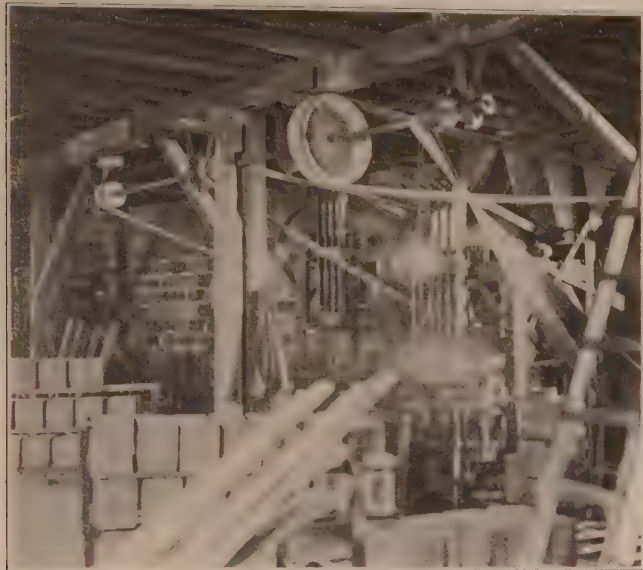
*A Blystone hydraulic block machine is operated in one of the buildings. It will make 4 block or 8 tile per minute*

This material can also be deflected into the silos. To reclaim material from the silos, a chain conveyor, operating at the floor of the silo, drags the material into the track hopper from which it is taken to the overhead bins as described.

The overhead bins are equipped with Blaw-Knox boxes which proportion the materials. Leaving the measuring boxes, the material is chuted into one of two 14-foot Blystone continuous mixers which are located on an overhead platform between the silos.

The mixers discharge through a chute onto a belt conveyor that serves the two Universal machines or into a feed hopper that serves the Blystone machine. Concrete for making the specials on the hand machines is taken directly from the belt as it is required.

The entire arrangement is extremely simple and effective. Only one man is needed to do all the proportioning



*Two Universal power machines operate in one of the plant buildings*

and mixing. A steady supply of concrete is automatically delivered to all of the three machines and the equipment used is inexpensive in first cost and low in maintenance.

### Cement Supply

There is only one weak spot in the layout and that is the present method of handling cement. Plans have been made to remedy this defect during the winter.

Cement is now received in bags hauled by truck direct from the cement plant about 9 miles away. The bags are stored in the building that houses the mixers and proportioning equipment. A cement pit has been dug in the floor of this building into which the cement bags are now dumped by hand. An enclosed bucket elevator lifts the cement to a feed bin equipped with a measuring box, above the mixer. The present method requires the services of a man for about 3 hours each day, filling the underground hopper, cleaning bags, etc. This man must be taken from his other duties for that purpose.

The new plan involves the use of bulk cement. Three steel boxes, each of 25-barrel capacity, with sloping hopper bottoms and a bottom dump door, will be constructed. One of these boxes will always be above the cement pit to fill it when necessary. This will be done by simply opening the bottom door in the box. The other two boxes will be loaded on the truck and taken to the cement plant to receive their charge of bulk cement. Arriving at the plant, the loaded boxes will be unloaded by means of an overhead trolley and hoist and placed in position over

the cement pit. With this arrangement an unfailing supply of cement will be available with practically no labor.

All the block are placed on racks by the machine operators. A man who operates a gasoline powered Clark truck lift keeps the three machines supplied with empty racks and places the filled racks in various locations in the building for inside curing. The truck lift makes it possible for this man to serve all the machines without delay.

The truck lift man gets to the plant about an hour earlier each morning to enable him to carry the loaded racks in the buildings out into the yard where the laborer piles them, taking back the empty racks to receive a new load. In this way the buildings are clear of block in the morning and ready for the day's work.

There is yard storage capacity for about 300,000 block and the entire storage area is paved with concrete to facilitate the operation of the Clark truck lift.

Deliveries of block are made on the company's own 5-ton trucks. An average load consists of about 350 block or 800 tile. Deliveries are made over a radius of about 9 miles. A trailer will be added to the equipment in the spring.

It has taken a lot of study and experimentation to perfect the methods and layout to their present high standard. The plant is now ready to make possible the objective of the manufacturers, namely, volume production of a few standardized products which can be sold profitably at a low profit per unit.

### Test of Bond Between Concrete and Hollow Tile Concluded

An investigation of the bond between concrete and hollow tile has just been completed by the Bureau of Standards. The factors covered by the tests included six different types of hollow tile and concrete mixtures of several consistencies and proportions.

The test specimens represented sections from a hollow tile concrete floor, each made up of two tiles joined by a concrete block 4 inches in thickness. The testing consisted in loading the concrete blocks by a heavy bearing block, the tiles forming the lower base. The desire was to obtain a shearing failure between the concrete. Results obtained indicate that the bond depends largely on the strength of the concrete, but this relation may be disturbed by using saturated tiles or damp curing. The condition least favorable to a good bond was found to exist when specimens were made from saturated tiles and then cured damp. This particular tile had an absorption of about 10 per cent. In general, damp curing did not increase the bond strength.

Specific factors which affected the bond strength were strength of the concrete, the stronger the concrete the greater the bond; absorption of the tile, no general law being observable and amount of water in the tile, the greatest bond being developed by dry tile, slightly less by sprinkled tile, and the least bond by saturated tile.

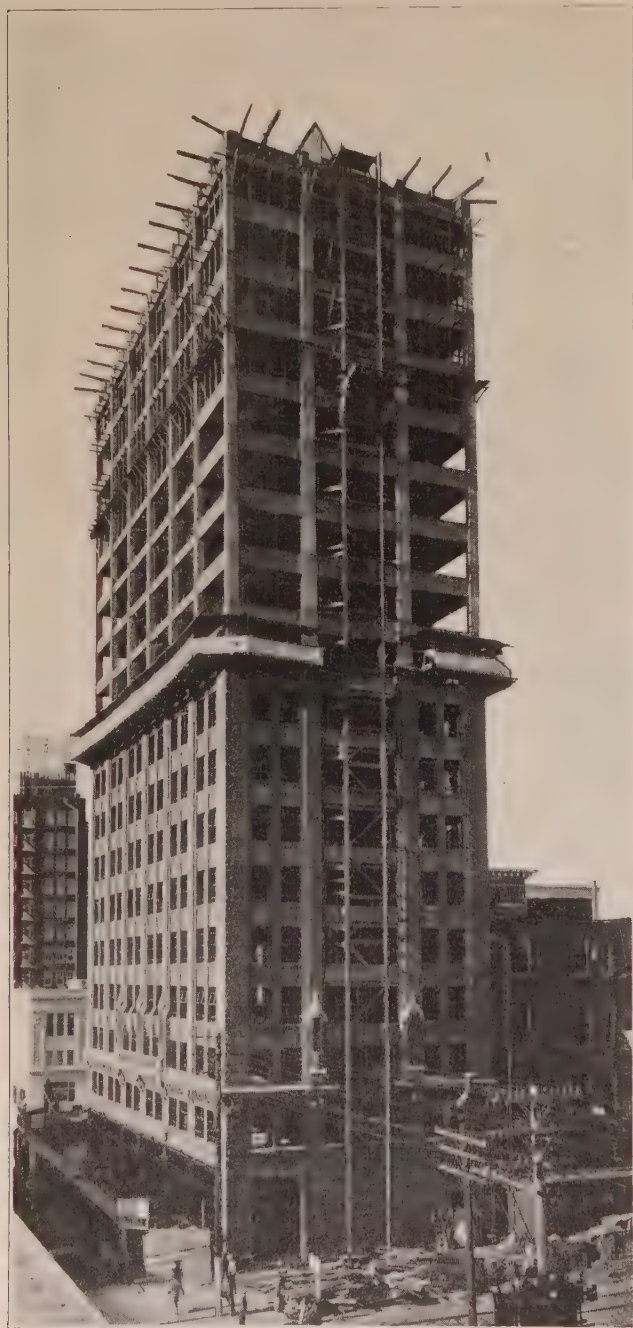
### New Underwriters' Laboratories Service

A new service for concrete block and tile manufacturers has recently been established by the Underwriters' Laboratories. This service supersedes the special label service outlined on Page 48 of our October number. Details of this new service will be published in an early issue.

## An 18-Story Reinforced Concrete Building on a 50-by 100-ft. Lot

An interesting recent example of the selection of reinforced concrete as the construction material for tall buildings of small floor area is the new Petroleum Building recently completed in Oklahoma City, Okla. This is an 18-story and basement office building in the heart of the business section. It is a tall, slender shaft, built to obtain the maximum efficiency in lighting in all the offices in the building. The structure was built during the winter of 1926-1927, and completed in the spring of 1927.

Although the building is 18 stories in height, it covers a lot of only 50 by 100 feet. This small floor area was the cause of several rather unusual features of design. Only 10 interior supporting columns were used. The construction was typical, with girders framing into columns and supporting ribbed floor slabs built on removable



*The Petroleum Building, Oklahoma City, Okla., is an 18-story reinforced concrete building with a floor area only 50 by 100 feet in size*

forms. Because of the small area occupied, considerable provision against wind pressure was found to be necessary. It is interesting to note that the transverse and first longitudinal girders were required to be considerably heavier than usual.

### Illustrates Design Advances

This reinforced concrete building represents one of several recent advances into a new field for reinforced concrete. Until recently it has been quite usual to build structures of such height and small floor area of a different material. The same provisions for wind bracing were made in the reinforced concrete structure as in any other. The floor areas were kept remarkably free from objectionable columns and a monolithic structure 18 stories in height was built.

It was found from the contractor's and the owner's estimates that a saving in the cost of the structural frame could be made by the use of reinforced concrete. Besides this saving in the original cost, it was possible to secure immediate shipments on all the materials used and the work advanced rapidly. Construction progressed at the rate of 2 floors in 7 days, which is remarkable even though the floor area was small.

The owner of the building is Mr. J. W. Mann, of Oklahoma City; the architects were Layton, Hicks and Forsythe, also of Oklahoma City; Hans Von Unwerth was the consulting engineer and the Mann Construction Company were general contractors. The contractor's supervising engineer, Frank L. Kebelman, was in charge of the building construction, and the building was financed by the S. W. Straus Company. The detailed structural plans were furnished by the Capitol Steel and Iron Company, under the supervision of Ralph L. Stevens, chief engineer.

## Rebuild Railway Bridge in Concrete in Two Days

An interesting stage in the program of the Southern Railway, one of the "Big Four" of the British railway world, for strengthening its bridges on its Chatham line, in order that engines of the heaviest and latest Lord Nelson and King Arthur classes may haul trains between London and the Thanet resorts and to Dover via Chatham, has just been completed. The job was carried out in record time.

The railway bridge carrying the old Chatham main line over the Strood and Maidstone line between two points just before the River Medway is reached, was entirely reconstructed, while at the same time a new length of railway connecting the Chatham line with the Southeastern line over the River Medway was brought into use, the cost of the whole work being about \$500,000.

The old bridge which was rebuilt had three spans and carried the double tracks of the Chatham line over the six tracks of the Southeastern line, four of which are sidings. New piers of reinforced concrete rest on piles and replace the old cast-iron trestle piers. The side spans over the sidings have been partially rebuilt without interference with normal traffic, but in order to complete the work on these spans and to renew the center span the Chatham line was closed on a recent Sunday, trains to and from the coast being diverted to another route.

Two 36-ton cranes were employed at the spot, and the whole of the work was carried out between 12 M. Saturday, and 6 a. m., Monday, just 30 hours, or one and one-fourth days. Gangs of men worked in reliefs at high speed during this period, at night by the aid of acetylene flares.

# Practical Kinks from the Job

## A Simple, Practical Bar Support

A VERY satisfactory job-made support for flat slab steel over column capitals can be manufactured of concrete at low cost by the concrete laborer with a simple hand mold, say experienced construction men who have tried various types of metal bar supports, many of which are difficult to maintain in an upright position, or at the required height.

The height of the support varies, of course, with the thickness of the slab, and to some extent with the method used for laying out or placing the steel on the forms and bending it. Generally, for flat slab jobs, where the bars do not exceed  $\frac{1}{2}$  inch or  $\frac{5}{8}$  inch in size, the bending can be done with a hickey after the steel has been placed. If this procedure is to be followed, the sequence of operations in placing the steel is usually along these lines:

The outside bars in the bands in one direction are placed first, the bars being carried directly by the bar supports. These bars hold up the bars in the bands running across the column head in the opposite direction, which are placed next. After these bars are all in place, the remaining bars in the first sets of bands are placed on top of them.

The steel drawings will usually show the distance from the surface of the floor to the bars in the top layer, or the band which is placed last. This is taken from the plans and a sketch made similar to Figure 1. The sketch shows the three layers of steel, and the way in which the required height for the bar support is worked out. Assume that the slab is 8 inches thick,  $\frac{5}{8}$  inch diameter round bars being used, with  $1\frac{1}{4}$  inch covering of concrete over top layer of steel. As will be seen from the sketch,

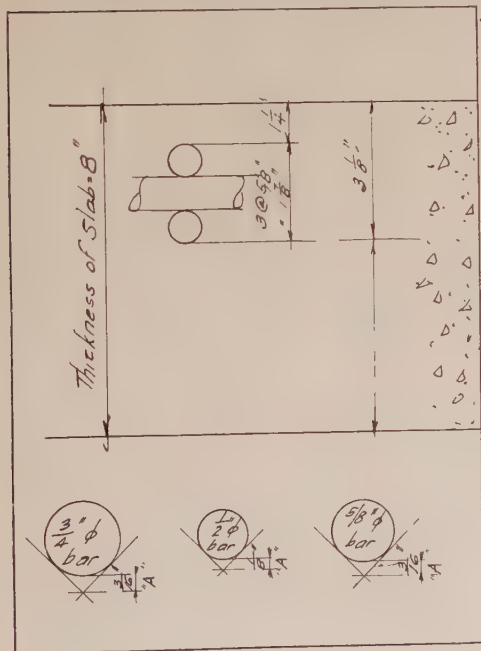


Fig. 1

the bottom of the lowest layer of bars will be  $3\frac{1}{8}$  inches from the top of the slab. To this figure must be added "A," a small fraction from the bottom of the bar to the bottom of the "V" cut in which the bars are carried. This fraction varies with the size of bar used. In the case we are considering it would be  $\frac{3}{16}$  inch, making a total of  $3\frac{5}{16}$  inches to be sub-

tracted from 8 inches (the depth of the slab) making the height of the block  $4\frac{11}{16}$  inches to the bottom of the "V" groove. This is the important dimension, as it fixes

the height at which the bars are supported.

The top of the block may be as much above the bottom of the groove as desired, but it is usually about  $\frac{1}{2}$  inch or  $\frac{3}{4}$  inch. This is not important as long as it is not above the top of the bar.

The angle at the bottom of the groove is  $90^\circ$ , as it is usual practice to employ a piece of skewback or bevel molding for this purpose.

A metal mold of No. 12 gage galvanized iron is then made by the nearest tinsmith, the mold being about 4 inches in diameter at the bottom and  $3\frac{1}{2}$  inches diameter at the top. The lap should be soldered or spot welded, and not riveted. A top is fitted into the mold, the top carrying on its under side the "V" shaped piece of wood shown to form the groove in which the bar will rest. A triangular groove seems to work out better than one semi-circular in section, because there does not seem to be the same tendency for the concrete to "pack" and stick in the top of the mold when the V-groove is used.

The concrete for these blocks is mixed quite dry, of a 1:2 mix, using sand and no coarse aggregate, and is tamped into the mold by a laborer with a heavy wooden paddle, the paddle usually being cut with a hatchet out of a piece of 2 by 4. The handle of the paddle is used for tamping, and the paddle end for finally compacting and smoothing off the bottom of the material in the mold.

In operation, the laborer generally has a sturdy work bench or table with a level place nearby on which to place the green block. Several pails of the concrete are heaped up on the bench, and the mold partly filled by turning it on its side and shoving the concrete into it with the paddle. The concrete is then tamped with the paddle handle, the process repeated, the mold struck off, and the mold turned over on the molding floor.

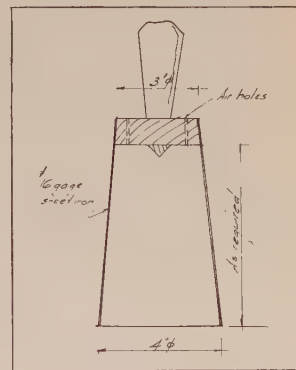


Figure 2

If the concrete is of the proper consistency, it will release itself immediately from the mold, and stand up without slumping or sagging.

The block can be piled the next day, if handled carefully, and by the time they are required, can be handled without care.

By actual comparison it has been found that a laborer mixing and one laborer making can turn out a far greater quantity of block than where an attempt is made to use gang molds. The labor of taking the gang molds apart, dumping out the blocks, cleaning and reassembling the mold, and cleaning, greasing and replacing the hundreds of metal spacer plates required for gang molds is far greater than for the method outlined above. In addition, the use of gang molds necessarily means the blocks must be square, making them heavier, more expensive and harder to handle than the round ones.

Other bar support kinks are invited. "Concrete" will pay from \$2 to \$5 for each accepted.

# The Future of Reinforced Concrete

Periods in the Development of Reinforced Concrete—  
Early Methods of Designing and Placing Concrete—  
Some Faulty Methods Still Used—Rationalization of  
Design—Standardization—The Present and Its Problems  
—Improving Concreting Practice—Factors Affecting the  
Durability of Concrete—Effect of Mixing Water on  
Porosity—Volume Changes in Concrete—Inelastic De-  
formation—The Future and Its Possibilities

By F. R. McMILLAN

Director of Research, Portland Cement Association

## Part II

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*Here is the conclusion of Mr. McMillan's searching analysis of the future of reinforced concrete.*

*Part I of this paper, which was presented at the semi-annual meeting of the Concrete Reinforcing Steel Institute on September 20, was published in the October issue.*

*In this and the preceding installment, Mr. McMillan frankly faces the problems confronting the reinforced concrete construction industry. He answers those who have criticized concrete unfavorably and suggests how further research and study can help to bring about greater progress in the concrete construction industry.*

*There is a message of vital interest to every concretor in this paper. If you have not yet read Part I, dig up your October issue and see how Mr. McMillan analyzes the present and future of the industry in which you are most interested.*

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EXPANSION and contraction due to temperature and changes in moisture content have long been recognized as inherent properties of concrete. These volume changes introduce problems in design just as the expansion and contraction in steel, and shrinkage and swelling of wood, produce certain forces that the designer in these materials must recognize. While these problems are not new, it is desirable that they be given more general consideration and serious study than has been given in the past. Provision for construction joints as well as for expansion and contraction joints should receive the same careful study as the other features of design, the plans should show definite locations for construction joints, and reinforcement should be provided to supply the continuity otherwise broken.

The provisions, which have been made in the past to take care of the movements due to volume changes, have varied almost as the number of designers, and as might be expected, the results have not been equally good. In certain cases, failure to provide adequately for these movements has brought about the necessity for important re-

pairs, but no serious condition has been reported where ordinary care was exercised in the planning. When the vast number of existing reinforced concrete structures is considered, the number where difficulties have developed is indeed small.

Besides the mere external movements which can largely be provided for by proper arrangement of joints and reinforcement, there is the problem of internal stress raised by the combination of steel and concrete. The differential movement due to temperature change is of minor significance because of the small difference in coefficient of thermal expansion for the two materials, but in the case of the changes due to moisture content the concrete alone is affected. The shrinkage accompanying drying out after initial hardening introduces a compression in the steel, which in the case of compression members, is a distinct advantage as it develops a higher unit stress in the reinforcement than would be possible if the load were proportioned between the two materials solely on the basis of their difference in elasticity. This advantage is recognized by the Joint Committee and the Committee of the American Concrete Institute on Building Regulations for Reinforced Concrete in their provisions for the design of reinforced concrete columns.

### Tension Members

In the case of tension members, such as the walls of circular tanks, the initial compression in embedded steel tends to increase cracking under load and is a decided disadvantage where liquids are to be stored. This, however, is now being overcome very successfully by constructing the walls of oil and water tanks with no embedded steel, the resistance to tension being provided by bands or hoops applied after the concrete has been allowed to shrink. This is not only a sound and practical method of meeting this problem, but is proving economical because the hoops are applied under an initial tension, thus permitting much higher unit stresses than were ever practicable in tanks with embedded reinforcement.

In the case of beams, the initial compression in the tensile reinforcement offers no advantage, nor has any ill result or disadvantage been shown by either test or experience; except that greater protection to the reinforcement may be required when there is possibility of penetration of moisture. Some engineers and others have seemed to see in these movements something of deep significance to the theory of reinforced concrete. Admitting the necessity of further research work and the possibility



*The United Brethren Building at Dayton, Ohio, twenty-one stories high. It is exceeded in height by one other reinforced structure and is equaled by another*

that eventually some modification of the theory may be desirable to recognize these variables, these should not be allowed to obscure the tremendous fact that reinforced concrete structures by the tens of thousands have been safely designed without reference to these possibilities, just as structures were for many years designed without reference to the secondary stresses that are now receiving so much attention.

#### Inelastic Deformation in Concrete

There is another problem that offers an interesting field for research. As in the case of volume changes, while much information has been available for years bearing on the inelastic deformation of concrete under load, it is only in recent years that designers have given attention to the problems which they raise. In the provision for column design in the report of the Joint Committee, recognition is made of the increased stress in the longitudinal reinforcement due to this inelastic deformation. In modern arch design, this phenomenon together with that of shrinkage is recognized, and in the more advanced practice, provision is made to reduce the moments due to rib shortening caused by these changes. This is accomplished by temporary hinges which are later removed. By taking advantage of the higher unit stresses in the reinforcement

due to these deformations it is possible to increase the economy of the arch ring design. In the design of arch dams, engineers are now recognizing these properties of concrete and making suitable provisions.

Within the past year, considerable interest has been shown in the problems raised by the shrinkage and inelastic deformations in concrete. Some of the earlier writings of the speaker, particularly Bulletin 3, Engineering Series, University of Minnesota, 1915, "Shrinkage and Time Effects in Reinforced Concrete," have been quoted in discussions of this subject. Some comment on the tests and discussion of this bulletin will be of interest. The numerical values of shrinkage and the time yield or inelastic deformation reported in that publication have since been confirmed by a number of investigators. These data have been the basis of the advances in arch, column, and dam design to which reference has been made.

Two passages from the concluding paragraphs of the Bulletin have particularly attracted attention.

They are as follows:

#### "Possible Effects:

"First, the continued yielding in the upper fibres of a beam coupled with the gradual breaking down of the concrete in tension may result in a progressive destruction of the bond from center toward the supports, similar to that occurring with the progressive loading of a beam as shown by Mr. D. A. Abrams (Bulletin No. 71, University of Illinois). Also the drying out incident to the large shrinkage movement may assist in this destruction of the bond.

"Second, the possibility of high stresses in the longitudinal steel of compression members seems to be the most important conclusion to be drawn from these tests. The time yielding of the concrete under stress combined with the excessive shortening due to shrinkage may result in deformations from five to fifteen times those expected from the ordinary calculations. In columns of the ordinary ratio of vertical steel in which no allowance has been made for the spirals the resulting steel stress is probably well within the elastic limit, but in those columns designed on the assumption of large loads being carried by the hooping the steel stresses may approach dangerously near the yield point."

These statements, as the text clearly implies, were attempts to interest the profession in the results of these tests by picturing the possible adverse effects in extreme cases. In the matter of columns, the purpose of the Bulletin was accomplished when the Joint Committee in 1921 recognized the basic importance of these inelastic deformations by providing a method of design that recognized them. In the matter of bond, no specific recognition has been given to the ideas advanced, but there has been an increasing tendency to improve the anchorage on all beam reinforcement.

It may be taken for granted that in the 12 years intervening since the publication of Bulletin 3, the speaker has given considerable attention to the problem raised by these two quotations. He has examined many structures built under every sort of condition and he has not found any evidence of progressive failure by bond, or other indications that would raise any doubts regarding the structural integrity and dependability of reinforced concrete. In the light of these 12 years of continued observation, it must be said that the prophecies of 1915 were somewhat overdrawn.

Let any who may have doubts as to the reliability of reinforced concrete, study the behavior of this material in the hurricanes in Florida and Cuba, or in the earthquakes in Japan and Santa Barbara, or in the tens of

thousands of buildings giving dependable service throughout the world.

### The Future and Its Possibilities

In view of the advances that have been made in the use of reinforced concrete in the past, can there be any doubt that the problems which it presents will be satisfactorily solved? With full assurance that the solutions will be found, some of the new fields for reinforced concrete may be briefly mentioned.

The extension of the use of reinforced concrete to the higher types of buildings within the past few years has marked an advance that should continue in increasing numbers in the future. The recognition by building regulations of high-strength concrete with commensurate unit stresses is not far distant and will greatly extend the field.

The use of concrete as a medium of architectural expression presents an opportunity for the extension of reinforced concrete probably unequalled by any single development since the invention of the girderless floor.

### "Concrete for Permanence"

Accompanying this opportunity and inseparable from it, there is a responsibility of equal magnitude—that of producing concrete exteriors which will endure. Repetition of the mistakes of the early history of concrete in this new field will be fatal. The present knowledge of the properties of concrete and concrete mixtures, if properly applied, will produce results eminently satisfactory. The proper application of the present knowledge means careful design, proper selection of materials, and complete control of construction operations.

The recent advances in the design of concrete arches, which permit the use of spans heretofore thought impossible, will also contribute to the development of the future.

In view of what has been accomplished in the past, there can be little doubt but that the use of reinforced concrete will continue to increase so long as the present balance of economic factors is maintained. With the continued improvements in practice in the light of past experiences and the results of research, further increase in the economy and usefulness of this material may be confidently expected.

## Charge Labor Conspiracy Against Cast Stone in New York

Charges that shipments of cast stone were prevented from entering the New York market was made in August at the opening of trial on the government's suit on the equity asking a restraining order on the ground that the Sherman anti-trust laws had been violated.

The suit was brought against the leading officers of the Journeymen Stone Cutters' Association of North America, and those of the Journeymen Stone Cutters' Association of Newark, N. J., and the Building Trades Council of West Chester County.

The government's contention before Judge Jacob Trieber, of Little Rock, Arkansas, sitting in the federal court, was that whenever cast stone was shipped the New York area union men would strike or in other ways prevent construction.

It was claimed that firms injured by this practice included the following: the Decorative Stone Company and the Economy Concrete Company, both of New Haven, Conn., Onondaga Litholite Company, Syracuse, N. Y., the Romberger Cast Stone Company, Allentown, Pa., George Rackle & Sons Company, Cleveland, Ohio, and the Linthicum Stone Corporation, Baltimore, Maryland.

## Associated General Contractors Issue National Safety Manual

A long step in furtherance of safety in the construction industry has been taken by the Associated General Contractors of America through issuance of that organization's Manual of Accident Prevention in Construction.

The manual is being distributed among general contractors in all parts of the country as a part of the accident prevention campaign launched intensively this year by the organization.

In the preface to the manual, W. F. Austin, President of the W. E. Wood Company, Detroit, and chairman of the Committee on Accident Prevention of the A. G. C., says in part:

"Information on accident prevention is very limited, although a number of books on accident prevention have appeared since the safety movement became a vital force in industrial safety work.

"The future progress of the accident prevention movement, the decision whether it shall advance with sufficient speed and strength to reduce the apparent increase of accidents in construction for which mass production and mechanical methods are largely responsible, rests with the general contractors of the United States. It is for them that this manual has been written."

More than 2000 copies of the manual already have been distributed from national headquarters of the association, located at Washington, D. C.

The table of contents of the manual discloses the following as titles of individual chapters: Public Demand for Safety; Voluntary vs. Mandatory Accident Prevention Effort; What Is an Accident?; Hidden Losses; Character of Accidents; Picture of Construction Operations; Greensfelder's Ten Cardinal Points; Extracts from Seth Sieder's "Constructive Talks to Pivot Men"; Extracts from National Safety Council Literature; Relation of Production to Accidents; Insurance and Rates; Estimated Savings; Character of Construction Executives; Character of Building Labor; Scheme of Organization; General Statement; Group Plan; Accident Prevention Committees; Safe Practice Rules; First Aid Classes; Statistics; Meetings; Bulletins; Board of Inquiry; Danger Signs; Cooperation with Other Agencies; Individual Plan.

## Coming Conventions

December 1st, 2nd, 3rd—American Construction Council, at the Hotel Statler, St. Louis, Missouri. Sixth annual convention.

January 4th, 5th, 6th, 1928—National Sand and Gravel Association, at the Book-Cadillac Hotel, Detroit, Michigan. Annual convention and machinery exhibit.

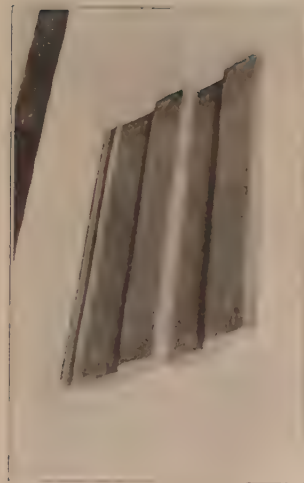
January 9th to 13th, 1928—American Road Builders' Association. Cleveland, Ohio. Convention and Road Show.

January 23rd to 27th—Associated General Contractors of America, at West Baden Springs Hotel, West Baden, Indiana. Convention and national construction exposition.

February 28th, 29th, March 1st—American Concrete Institute, at Benjamin Franklin Hotel, Philadelphia, Pa. Twenty-fourth annual convention.

# How to Make and Sell Concrete Roofing Tile

Development of Concrete Roofing Tile—Types of Tile—  
Specials — Colors — Manufacturing Methods — Costs—  
Placing the Tile on the Roof—Markets and Merchandising  
Methods



**C**ONCRETE roofing tile are not a new factor in the concrete products field. Though Europe was the scene of the introduction of concrete roofing tile, they have been made and used in the United States in very limited quantities for twenty years or more.

The early manufacturer had many problems to contend with. Competing interests did their utmost to prevent the establishment of the new tile and the manufacturer had many problems of his own such as design and color to solve.

Gradually these problems have been solved and the past few years have seen a remarkable increase in the manufacture and use of concrete roofing tile.

Concrete roofing tile cannot be considered a concrete products specialty in the sense that ornamental garden furniture, burial vaults, etc., are. Their manufacture constitutes a major branch in many plants and in the majority of cases is the sole output. But they do offer the concrete block manufacturer an opportunity to extend his activities and to add a department to his plant that rounds out his opportunity to supply permanent building materials. The manufacture and sale of concrete roofing tile fits in well with the manufacture and sale of concrete block or building tile and often the block manufacturer has a ready roof tile market in his block sales territory.

## Development of Concrete Roofing Tile

Germany is usually given the credit for developing the concrete roofing tile. Here it was introduced to meet a definite need. There was no such an array of roofing materials available as in America. Slate and wood were not to be considered. The market was ready and waiting.

Little attention was given to appearance. Crude shingle tile were used, having no color other than the natural gray of the cement. Sometimes the tile were dipped in black bitumen to waterproof them.

Some 20 to 25 years ago references to concrete roofing tile in America began to appear in CONCRETE. Many of these tile were, undoubtedly, badly made, but they were the forerunners of the roofing tile industry of today. The effort to develop a red tile, similar to the clay tile, introduced the color problem which has not yet been entirely solved to the satisfaction of all roofing tile manufacturers.

The steadily increasing desire for non-inflammable roofs is probably one of the principal reasons for the rapid growth in the use of concrete roofing tile in the past few years. The National Board of Fire Underwriters has endorsed the concrete roof tile strongly. When it is realized

that a third of the dwelling house fires that cause an annual loss of around \$65,000,000, start on roofs, the value of a fire-resistant roof is obvious. Add to this the increased quality of concrete roofing tiles, the range of color and style now available and the increasing popularity of those types of architecture that demand Spanish

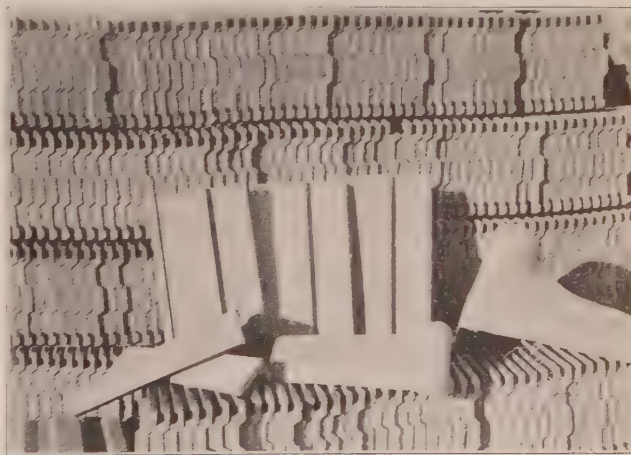


*Showing the use of concrete roofing tile on concrete block houses of varying styles of architecture*

or French tile roofs, and it is easy to see the reason for the growth of the concrete roofing tile industry.

## Types of Concrete Roofing Tile

There are two general types of concrete roofing tile for residences—the Spanish and French. These two designs in various color combinations meet the architectural needs for practically all types of dwelling houses. There are also some types of larger concrete tile used primarily for roofing industrial buildings. There are, of course, a variety of ridge and hip tile units, known as specials. These include gable terminals, hip starters, hip rolls, ridge



*A stack of concrete roofing tile. Some of the specials are also shown*

rolls, hip terminals, etc.

The average tile size is about 9 by 15 inches, the sizes varying slightly with the machine that is used for making them. From 100 to 150 tile are required per square, depending on the size and type of tile used. Each square weighs from 700 lbs. to 825 lbs., the weight also varying with the type and make of the tile. Clay tile weighs from 900 lbs. to 1800 lbs. per square, slate from 700 lbs. to 2000 lbs., and composition roofing from 250 lbs. to 600 lbs. depending on the material.

### Manufacturing Methods

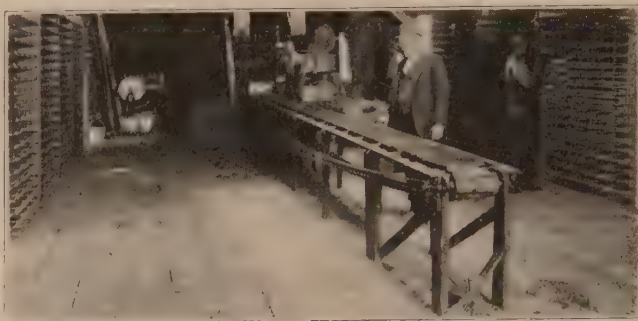
In the earlier development of concrete roofing tile all of the units were made on hand machines. The hand machine is still considered by some as the most satisfactory equipment, though automatic power tamp tile machines are being operated with success in a number of large tile plants.

The manufacture of concrete roofing tile, whether the hand tamp or the power machine is used, is not a difficult process. But here, as in all other concrete products, the fundamental requirements for making good concrete must be observed.

Roofing tile are made on pallets inside a removable frame. In the hand machines the concrete is placed in the mold box on the pallet by hand. The concrete is then com-

pressed, struck off and trowelled with a strike-off bar that operates on guides which are a part of the machine frame. Color is then applied and the pallets containing the tile are racked and taken to the curing rooms.

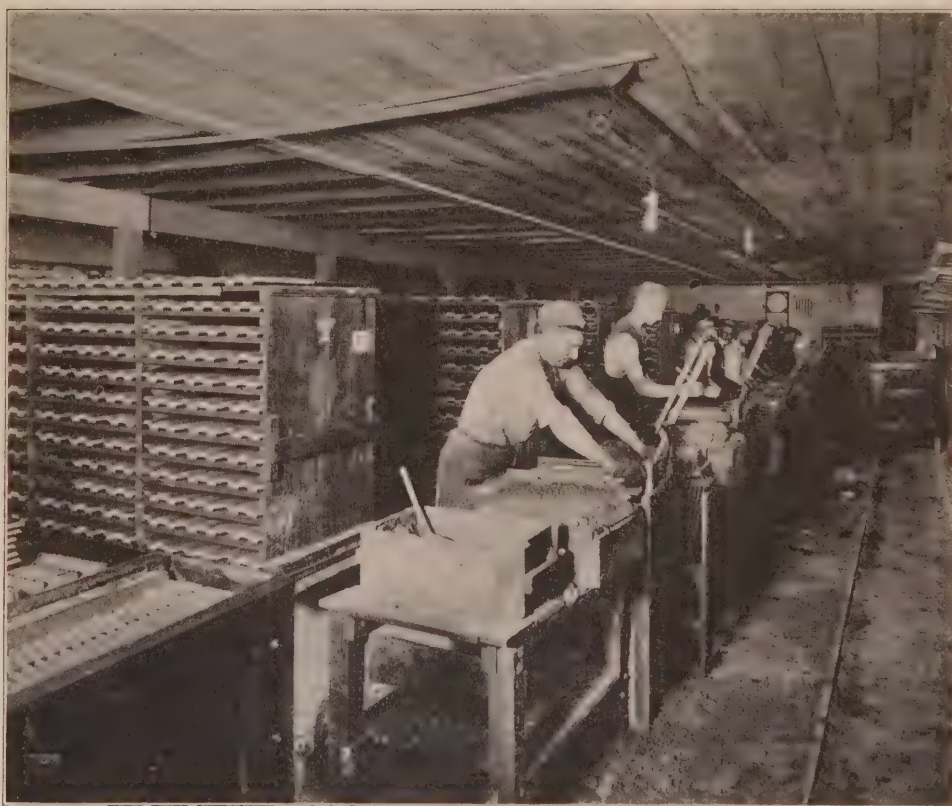
A relatively dry mix consisting of one part of cement to three parts of clean, sharp sand is recommended.



*An automatic roofing tile machine*

### Applying the Color

A most important item in the manufacturing process is the application of color. From the standpoint of the home owner, color is of greatest importance and the manufacturer cannot exercise too much care in selecting his materials and applying them. The success of the tile is largely



*A battery of hand machines in a concrete roofing tile plant*

pressed, struck off and trowelled with a strike-off bar that operates on guides which are a part of the machine frame. Color is then applied and the pallets containing the tile are racked and taken to the curing rooms.

When automatic machines are used, the pallets are usually fed onto a continuous chain horizontal conveyor. The conveyor carries the pallet under a hopper where it receives the concrete. The pallet then passes under a pressure device where the concrete is shaped and tamped. The conveyor next takes the tile under a color hopper where

dependent on securing permanent color.

The experiences of successful roofing tile manufacturers have shown that satisfactory colors are available and that a good quality non-fading product can be made. Color pigments must be of pure mineral oxides and should be purchased from reputable concerns who will guarantee their products. Oxide of iron is used for red and chromium oxide for green.

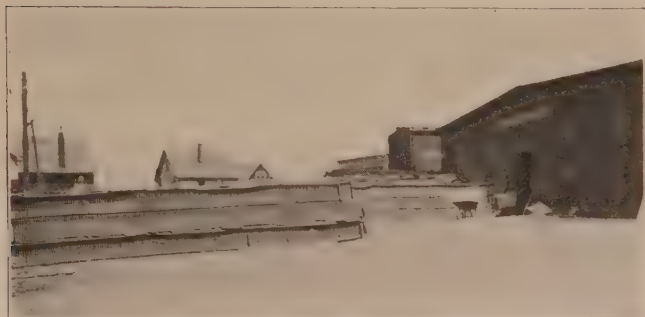
Color is usually applied dry and tamped into the face or weather side of the tile. The color is usually sifted on

with a perforated shaker. The surface is then trowelled again until the surface is of a uniform color. Some tile are treated with several colors, as, for instance, red and yellow or blue and grey, etc. Any variety of color combinations to suit any architect or owner can be secured.

### Curing

When the tile leave the machine, they are racked up with the butts outward so that the edge of the tile which is exposed on the roof can be colored like the upper surface.

In an article as thin as a concrete tile with such a large exposed surface area, curing is of vital importance. Steam curing rooms have been found to give the best results. It is recommended that the steam should not be turned on until three hours after the tile is made to prevent the possibility of injury to the color. Temperatures of from 90 to 130 deg. Fahrenheit are maintained for 48 hours after which the tile is removed from the pallet and stored. All that is necessary to remove the tile is to tap the pallet. The pallet should be thoroughly lubricated before it is reused.



*A stock pile of concrete roofing tile. There is a large market for this product awaiting development*

The tile should be stored indoors and kept wet by sprinkling for an additional 10 days after they are taken from the curing rooms. Indoor storage space for 10 days' production is required. Manufacturers have found that this matter of indoor curing has an important bearing on the success they have with colors.

### Laying the Tile

Many a good roof has been spoiled by incorrect application. It is necessary to see to it that tile is correctly laid as well as carefully made. For this reason many concrete roofing tile manufacturers apply all their own roofs. They will sell only the finished roof and will permit no one else to lay their tile. Other manufacturers select a few roofing contractors in whom they have absolute confidence and insist that one of them be selected to place their tile. Whatever the arrangement decided upon, the manufacturer must be assured that the tile will be properly placed if his product is to be regarded with favor.

An accompanying illustration shows the method recommended by one manufacturer. Best results are obtained if the roof has a pitch of at least  $\frac{1}{4}$  inch. Concrete tile should not be put on "open construction." It is difficult to make an absolutely watertight roof in this way. The roof should be sheathed solid, well braced and covered with felt or tar paper before the tile are applied. Cleats are then attached as shown and the roof is ready to receive the tile.

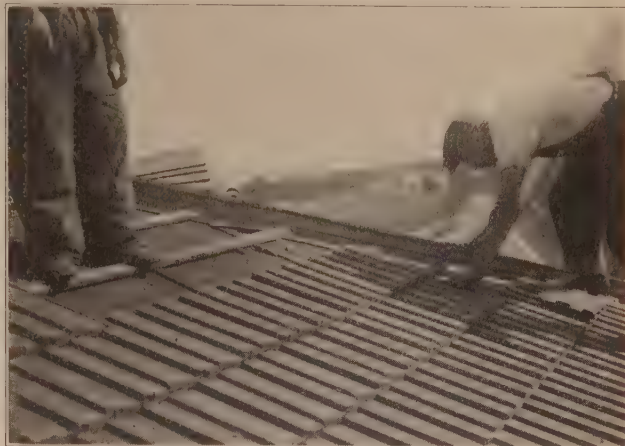
A hoist and tackle for lifting the tile to the roof has been found very helpful.

### Merchandising

It is not a difficult matter to determine whether or not there is a potential market for concrete roofing tile in your community. Authorities estimate the possible market

at about 200 squares per thousand of population annually. This includes both new buildings and the reroofing of old buildings.

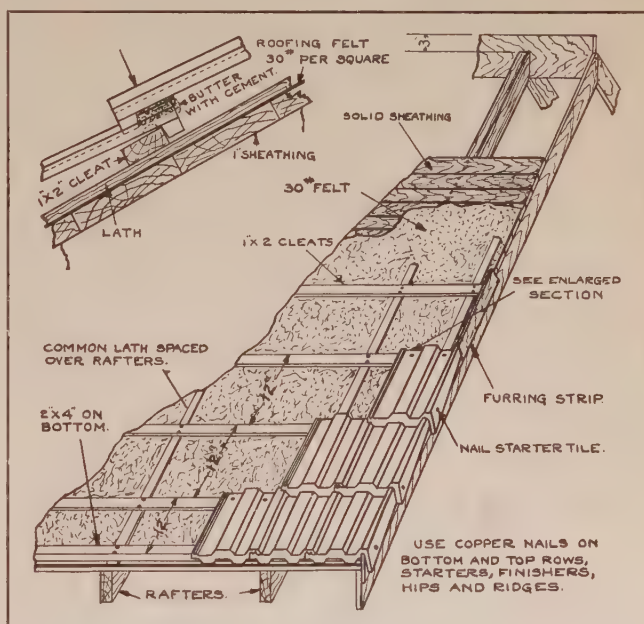
With the present trend toward fire safe and permanent construction, much of the sales resistance that the older tile manufacturers had to fight against has already been



*Showing method of laying roofing tile*

overcome. Home builders are beginning to realize the advantages of permanent fire safe roofs.

A most important field for the sale of roofing tile is in the reroofing of old houses. The number of houses reroofed each year in your sales area can be determined approximately by dividing the number of houses by 20, which is the average life of a non-permanent type of roof. One manufacturer of roofing material has a record of the



*Method recommended for placing concrete tile on roofs*

houses in his sales area, giving the owner's name, the age of his house and the type of roof. From this record he selects those whose roofs should be ready for replacement and classes them as sales prospects to be called upon and supplied with literature.

The concrete roofing tile manufacturer has some very strong arguments in favor of his product. Among them are:

1. Beauty. Any range or combination of color is available.

2. Permanence.
3. Low cost, especially when considered over a period of years.
4. Precision. Concrete tile are made absolutely true in shape and dimensions. They lay perfectly on the roof, making even contact.
5. Ease of laying. The regularity in size and shape makes for speed in laying. It is never necessary to match tile for shape and color.
6. Concrete tile competes only with such expensive types of roofing as slate and hard burned clay. Wood, asphaltic and "paper" roofs cannot be considered as competitors.
7. Fire safety. Many city building codes prohibit the use of combustible roofings. Concrete tile are recognized as having the highest rating in fire safety.

### Investment Required

There is a wide range in cost of roofing tile machinery and equipment. An entire new plant would require an investment of considerable size, but the block manufacturer who is "feeling out" his market before investing heavily can do so by purchasing one hand machine and adding to his equipment as his market expands.

A hand tamp machine that will produce about 375 tile (or  $2\frac{1}{2}$  squares) per day will cost in the neighborhood of \$500. For each machine about 500 pallets will be required. These will cost, roughly, \$250. Add to this the cars and racks needed and tile can be made on a limited scale. This estimate is made on the basis that the manufacturer already has the necessary mixer, power equipment, curing room and space required. Sometimes the cars and racks used for concrete block can be adapted for concrete tile manufacture.

An automatic machine, costing around \$5,000 will make approximately 28 squares of tile per day. With such a machine, the investment in pallets, cars and racks, conveyors, etc., will be proportionately greater.

It has been estimated that quality concrete tile can be made on a hand machine for \$7.50 per square in the yard, exclusive of delivery, selling and laying expenses. A similar estimate for automatic machines in a plant producing 28 squares per day, is about \$5.50 per square in the plant yard. Manufacturing costs, of course, vary greatly in different localities and even in different plants, so that estimates of cost that apply to one plant may be high or low for another.

With the color problem practically solved, and a new conception of merchandising being developed in the concrete products field, the growth of the manufacture of concrete roofing tile is assured. The market is there, the product is good and the cost is reasonable.

## Undersea Concrete Research Producing Good Results

The committee appointed by the British Institute of Civil Engineers to investigate the deterioration of concrete, metal and timber structures under the sea, and which has been doing so since 1916 with the assistance of grants from the Department of Scientific and Industrial Research, has just issued its seventh interim report. This report is chiefly occupied with the progress of investigations instituted at an earlier date and the results that have been obtained from them up to now.

The observation of changes that are slow in their action must be prolonged over considerable periods, and as yet it is not time to draw definite conclusions. The data that are being accumulated, however, seem to be such as to warrant the confident expectation that the ultimate result

of the various investigations conducted by the committee will be to yield data of fundamental importance to those who are responsible for structures exposed to the action of sea water both above and below water level.

Some contribution is being made to the cost of the work by various dock and harbor authorities in the United Kingdom and in the British overseas dominions.

The chief information regarding concrete contained in the report is information received from J. Marchbanks, chief engineer of the Wellington Harbor Board, New Zealand. Mr. Marchbanks supplies data on the exposure for seven years of two reinforced concrete piles of 1:1½:3 mixture, 10 feet in length, with the reinforcement so placed as to give depths of cover 1 inch, 1½ inches, 2 inches and 2½ inches respectively, the lowest 2 feet being always submerged, and the remaining one-half being subject to the rise and fall of the tide, and the other half above water level.

A thorough examination, removing a length of cover, has shown that the pieces are perfectly sound and everywhere free from rust. The cover has been repaired where stripped, and the exposure is being continued, in the hope of obtaining ultimately information as to the protective value of increased depth of cover.

## Interesting Rebuilding of Bridge in Switzerland

The iron railway viaduct at Grandfley, Switzerland, which was constructed some 65 years ago, was found in 1922 to require very considerable strengthening in order to enable it to carry modern electric railway traffic with due regard to safety. Inasmuch as the expense of demolition and entire reconstruction would have been exceedingly heavy, the engineers inquired into the possibility of making the structure serviceable in some more economical manner.

As originally constructed, the viaduct was 1,246 feet in length, carrying the railway at a maximum height of 246 feet above the valley. It comprised seven continuous lattice girders of 157 feet 6 inches each, the whole supported by masonry abutments and six intermediate piers. The lower part of each pier was of masonry to the height of 105 feet at the lowest point in the valley and the upper part of each consisted of a cast-iron tower, 141 feet 8 inches high.

In the scheme finally approved for strengthening the bridge the masonry piers were made good where necessary with concrete, and reinforcing bars in some places. The cast-iron towers were completely encased in masonry as they stood and were consolidated by the addition of concrete. The next item in the program called for the removal of the iron girder spans, and, in order to carry out this operation with a minimum of interference with traffic, reinforced concrete arches were constructed from the abutments and piers for the support of the decking before removing any of the girders. Each new arch comprises main ribs, from which rise spandrel columns connected at the top by arches, and constituting two parallel arcades supporting the decking of the viaduct and also a public footway at a level just above the extrados of the main arch ribs. When once the weight of the decking and its loading had been transferred to the reinforced concrete arches, the demolition of the iron girders became a simple matter.

The viaduct today is to all intents and purposes a reinforced concrete structure of very pleasing appearance and capable of carrying the heaviest railway traffic with perfect safety.

# The Essentials of Rigid Frame Design

## A Discussion of Rigid Frame Construction as It Is Used in Europe—Advantages of This Type of Structure—The First Steps in Designing Rigid Frames

By E. H. HARDER

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### Part II

IT is the purpose of this article to describe some of the fundamental principles, not readily found in English literature, according to which the European engineer designs his rigid frames. Available space prohibits a discussion of the arch principle, as applied to the rigid frame, and for this, the reader is referred to textbooks or to some of the proceedings of our national societies.

#### Preliminary Design

Usually the first step in the design of rigid frames is to make the preliminary drawing of the frame upon which the final design is to be based. The usual spacing of frames, in the longitudinal direction of the building, is from 14 to 20 feet, the most common practice placing this spacing at 16 feet center to center of frames. The roof girders (purlins) are designed for the selected spacing of frames and the roof slab is computed in consonance with the purlin spacing. The thickness of the frame and the depth of section from point to point must be estimated according to judgment and experience. The minimum depth of section of the arched portion of the frame, from the lower steel to the outermost concrete edge, is about  $1/20$ th of the span length. In general, the frame must satisfy the space requirements of the building for which it is to be used. If the frame is a simple one, the preliminary design may be quickly checked by using those applicable formulae found in some American textbooks or those published by Kleinlogel in his book on "Rahmenformeln." A more complete and careful check will require other methods not under discussion here.

#### The Gravity Axis

For such an analysis, the axis of the frame must be determined because it is this axis which is deformed by the external loads and reactions. Textbooks on the reinforced concrete arch speak of the gravity axis of the arch upon which the external loads and reactions are assumed to act and place this axis midway between the extrados and the intrados. If every cross section of the rigid frame is rectangular, it will be sufficiently accurate to assume its gravity axis to lie midway from the outside to the inside of the frame at all points. Actually, this gravity axis would be the locus of the centers of gravity of each section of the frame with full consideration given to the tension and compression steel and omission of the ruptured concrete in the tension zone. Strictly applied, such a procedure would be an endless operation and one would have a different gravity axis for every change of load. Consequently, the usual practice is to use the gravity axis of the full concrete section and if the latter is T-shaped, the gravity axis would naturally be shifted toward the flange of the section and would not lie at the center of the rectangular stem. The real complexity of the problem

and the uncertainties of the elastic theory applied to the design of indeterminate structures of reinforced concrete, as viewed from an ultra theoretical standpoint, preclude any great refinement of the attempted location of the gravity axis upon which subsequent computations are based. After all, there are good reasons, based partly on experience and partly on tests, to suppose that the internal stresses are not as great as those computed according to the elastic theory and each section of the frame is finally reinforced according to theories of stress distribution which likewise give safe results.

#### Moments of Inertia

The next step is to compute the moments of inertia of the sections of the frame because these enter directly in the subsequent computations of the deformations of the axis of the frame. These moments of inertia are computed about the gravity axis previously described. Here, the designer, if he has had much experience in the design of frames, may estimate the amount of steel required for tension as well as compression and then compute the moment of inertia by using the full concrete section and  $n$ -times the moments of inertia of the steel areas about the gravity axis of the section. Since the elastic theory is based on relative stiffness, the common practice is to compute the moments of inertia for the full concrete section about its gravity axis regardless of any steel which, at this stage of the work, is still an unknown quantity. If the arch portion of the frame has a T-section, the moment of inertia of the full T-section is computed even to the ends of the arch where it is apparent that there will be a change in the sign of the bending moment from plus to minus and where, in the final analysis, the flange is not considered as a tension member.

A more accurate analysis of the indeterminate reactions can now be made after which, the normal thrusts, shears and bending moments for any cross section of the frame may be computed. Following this, the sections of the frame may be more carefully redesigned and if found to vary greatly from those of the initial assumption, the entire work must be repeated until a satisfactory agreement between the assumed frame and the computed one is reached. For small and unimportant frames, the first trial will generally give satisfactory results but for large and important ones, the complete computation may need several repetitions before the satisfactory agreement is found.

#### Temperature Variations

For ordinary buildings, one may disregard temperature variations. When designing rigid frames or other arched structures of large span length, the effect of temperature changes should be considered. If the concrete of the frame is poured in spring or fall, a temperature variation of

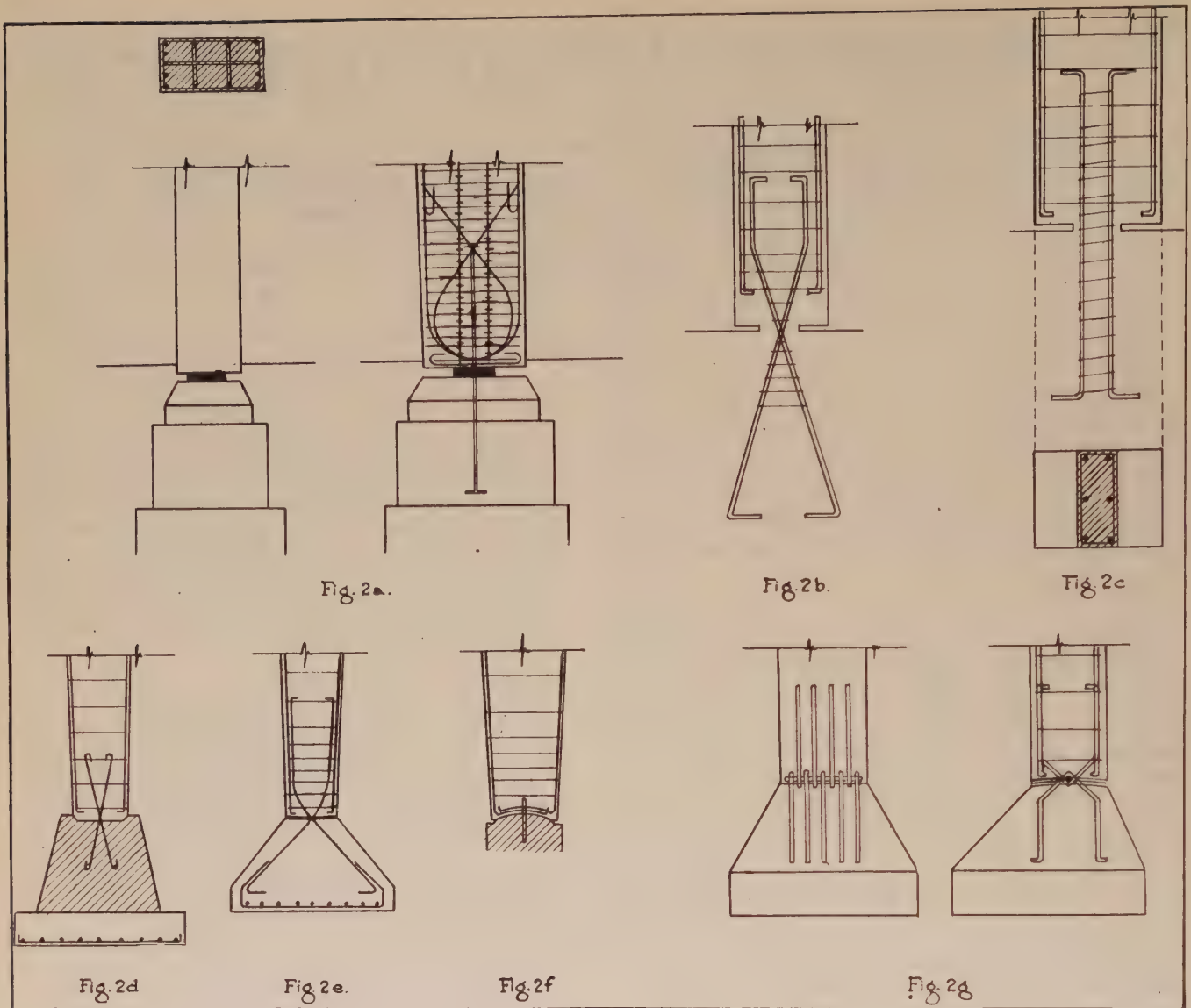


Figure 2

25 degrees F. will suffice but if the concrete is poured in winter or summer, during the extremes of annual temperature variations, the above range must be altered according to the conditions. If shrinkage is to be considered, its effect is equivalent to a temperature drop of about 27 degrees F. The coefficient of thermal expansion for reinforced concrete is about 0.000055.

For the computations of the external reactions of the indeterminate frames,  $E$ , the modulus of elasticity is taken at 3,000,000 lbs. per sq. in. and  $n = 10$ . When computing the amount of steel reinforcing needed at various sections of the frame " $n$ " should be equal to 15.

In general, the allowable maximum stresses in concrete and steel, as permitted in European practice, are 40 kg. per sq. cm. (570 lbs. per sq. in.) and 1,200 kg. per sq. cm. (17,100 lbs. per sq. in.) respectively. If, in addition to dead load, wind load and crane loads, the effects of snow loads, temperature variation and shrinkage are included in the computations for the external reactions, then the above allowable concrete stress may be raised 30 per cent or to 740 lbs. per sq. in.

#### Steel Reinforcement

Knowing now the normal thrusts and bending moments at all sections of the rigid frame, the designer's next task will be to compute the necessary steel reinforcement. Not

only will it be necessary to reinforce each section of the frame to resist tensile stresses but it may be necessary to add compression reinforcement. For variable loads acting on the frame, such as wind and crane loads, reversal of stress at the various sections is indicated and the reinforcement along the outside and inside of the frame must be sufficient to take care of the stresses involved. This task would be laborious were it not for the simple, yet accurate, methods to follow.

#### Hinges

In Fig. 2 are shown a variety of hinges which have been used in structures in the past. The list is by no means complete but it is sufficiently inclusive to give the reader a fair idea of the nature of the hinges commonly used.

In reinforced concrete construction, a structure may be considered completely hinged, if the hinge is of such character that the structure rotates about the center of a pin, or partially hinged if any of the types shown in Fig. 2 are selected. Of these, Fig. 2g comes nearest representing a complete hinge, as far as one may judge from looks, but the upper part does not bear on the bar shown through the center of the hinge but it does bear on the slightly curved upper surface of the abutment.

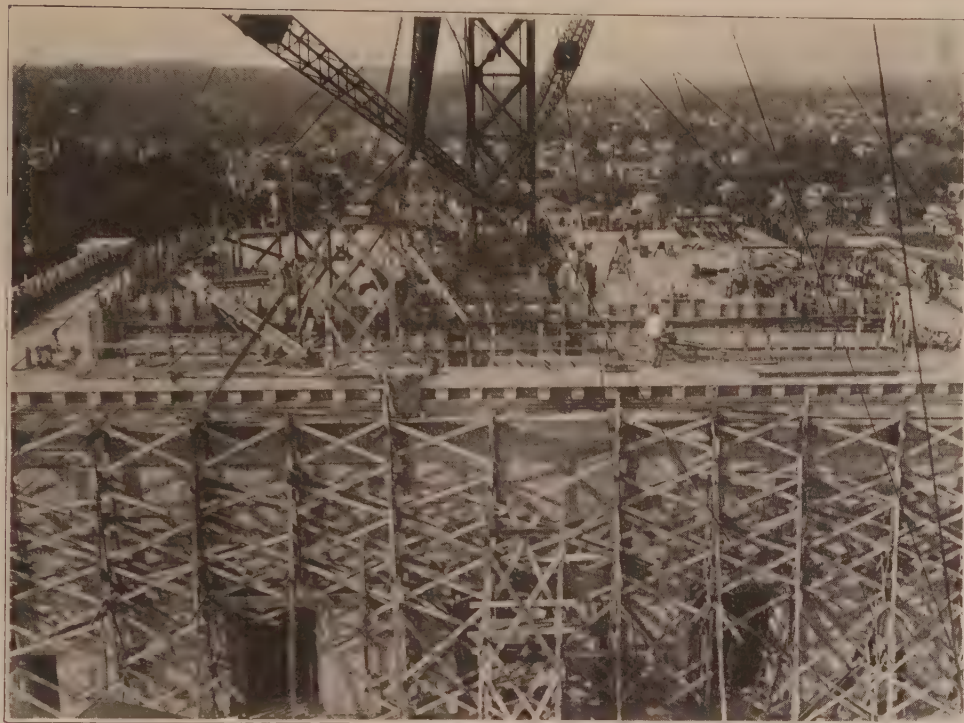
Fig. 2a shows a hinge where a thick lead plate sepa-

rates the two halves coming together at the hinge. The rods through the center would be constantly in flexure. The remaining hinges are adaptations of the Mesnager hinge Fig. 2b or the Considere hinge Fig. 2c. As partial hinges, all of them have some commendable features as well as faults and this makes it difficult to recommend any particular type for universal use. The design of the

hinge depends largely upon the character of the structure of which it is a part as well as the load it is called upon to bear. For heavy construction, one may prefer the Considere type to the Mesnager type; while for light short span frames, either would be too "fussy" and such hinge as shown in Fig. 2f would be perfectly satisfactory.

(To be continued in the December issue of CONCRETE)

## Largest Roof Slab Placed on National Masonic Building



The George Washington National Masonic Memorial Temple at Alexandria, Virginia, has as its roof the largest concrete slab in the world. Dimensions over all are 78 feet 8 inches wide, 110 feet long. Supporting beams are 72 feet long by 14 feet 6 inches deep, varying in thickness from 1 to 5 feet. Each supporting girder contains  $7\frac{1}{2}$  tons of steel reinforcing rods.

The beam span is broken by 8 concrete columns, each 40 feet high and weighing 68 tons. The concrete corner piers are 9 feet square. Almost 1,000 cubic yards of concrete were used in the 3-foot roof slab.

Completion of the structure is planned for the spring of 1930.

—Henry Miller News Picture Service, Inc.

## Japanese Find Way to Make Artificial Marble from Magnesia Cement

Tokyo, Japan—The Mineral Chemistry Division of the South Manchuria Railway Company Central Laboratory, Dairen, has succeeded in manufacturing artificial marble from magnesia cement. The credit is due to the experts of the Central Laboratory staff who have been prosecuting the study of this particular branch of research since 1918. The formality of taking out a patent for the new invention is being undergone.

The manufacturing process is very simple. Magnesia cement is first mixed with a certain chemical and a necessary amount of toilet powder, and kneaded together with water. This mixture becomes solidified to form a sort of lignified substance usable as a substitute for linoleum.

By applying asbestos and cork powder, a hard artificial marble may be put out excellently suited for walling purposes. The price is only 12-13 sen per pound. This marble is fireproof.

The application of magnesia to the manufacture of lignoid was completed in 1918 and the latter is being manufactured and sold by the South Manchuria Industrial Company, Ltd.

It has, however, two drawbacks. It absorbs moisture and lacks luster, making it unsuited for use in Japan, where the humidity is very high. The new invention

means a conquest over this drawback by succeeding in turning out a building material having good luster and solid strength. The magnesite reserve in South Manchuria being roughly estimated at 20,000,000,000 tons, the economic possibilities of this new invention are believed to be enormous, particularly now when the permanent reconstruction of Tokyo and Yokohama after the great earthquake and fire is being faced.

## New September Construction Mark Established

Construction operations, holding to the record-breaking habit acquired during the mid-summer weeks, in September reached the greatest volume ever registered for that month of any year, according to statistics compiled by the Associated General Contractors of America. These statistics, based upon shipments of basic construction materials and including all types of construction, also show that only one other month—August of this year—ever rolled up a greater volume.

September's activities enabled the current year to retain the margin it held during recent months over the volume of work carried on during corresponding periods of 1926. The total for the first nine months of 1926 is four per cent smaller than the total rolled up since the opening of the current year.

# Relation Between the Characteristics of Portland Cement and Deterioration of Concrete

## Dense Concrete Is the Most Durable Concrete—Waterproof Concrete Is Durable—Possible Improvements in Manufacture of Portland Cement and Their Effect on the Durability of Concrete

By JOHN R. BAYLIS

Filtration Engineer, Bureau of Engineering, City of Chicago, Ill.

### Part V—Improving the Durability of Concrete

WITH the limitations of concrete for exposed structures defined in the preceding articles, the question arises as to how best to make more durable concrete.

If its use was confined to the inside of buildings where it would never come in contact with water, the manufacture of concrete would be almost entirely a question of the proper strength. It is possible to make concrete that will be durable for most exposed conditions, but it will require some changes in present methods of construction.

The water-cement ratio is a step in the right direction, but it will not insure all the concrete being durable. It is impossible to set a definite limit on the amount of water and get uniform concrete. It should be made just wet enough to work into the forms and around the reinforcing steel, and also to the point where considerable working will not cause the coarse aggregate to separate from the mortar. The water-cement ratio was worked out primarily as a means of predicting the approximate strength of concrete and has nothing to do with durability, except that in the production of the strongest concrete it is necessary to have a dense mixture.

#### Dense Concrete is the Best Means of Insuring Durability

The top finish of a well-made concrete sidewalk or floor is usually excellent concrete and will stand many conditions of exposure where ordinary concrete disintegrates. It might be argued that the proportion of cement to fine aggregate is usually greater in this case, and that a good quality of fine aggregate is always used. This may be part of the reason, yet if the same ratio of cement and aggregate were used and the mortar made as wet as it is within much of the wet mixed concrete, it would not be so durable unless worked together after the excess water has escaped. The amount of cement and the excellent quality of fine aggregate are not all that make the top finish of a sidewalk durable. It is the compacting of the mass by working it together after part of the water has escaped. Good materials are one essential, but troweling the surface to materially lessen the voids is a very important procedure.

The mortar in wet mixed concrete has from 35 to 45 per cent of its volume in voids when determined by the writer's proposed void test, whereas the voids in the cement finish of a sidewalk after troweling are usually less

than 20 per cent. This lower percentage of voids represents a material lessening of the passageways leading from the outside of the concrete to the interior. Under most conditions of exposure the cement finish of a sidewalk is so dense that the high calcium cement compounds are carbonated to only a very shallow depth, frequently less than one-eighth of an inch. When this is compared to an inch or more for wet mixed concrete it is a great difference. The voids in the sidewalk finish are filled with calcium carbonate near the surface before all the high calcium cement compounds are broken down. Such concrete is not exactly a solid mass, but it has many of the characteristics of a solid; that is, attack is largely from the outside inward. As previously stated, serious weakening of the concrete by attack from the outside is such a slow process that it is of no great consequence for most structures.

#### Waterproof Concrete is Durable

Water travel caused by moisture evaporating from the concrete surface may be great enough to eventually weaken most any concrete, but the time required to weaken dense concrete to the point of failure is very much longer than when it is more porous. Concrete should be made as impervious as is practical to make it, for this is the best insurance of durable concrete. Protective coatings may be applied to the surface or waterproofing compounds may be used in the concrete, but neither of these are as good as making the concrete very dense. We have no assurance that the waterproofing compounds will give permanent protection or that protective coatings will last a great many years.

If it is not practical to make very dense concrete, as may be the case in some instances, then the concrete that is likely to be exposed to the weather or to water should be waterproofed. All surfaces where water can enter the concrete and all surfaces where moisture may evaporate should be protected with a water-tight film of some good waterproof paint if durable concrete is desired, and the paint should be renewed wherever it starts to give way.

Some of the concrete exposed to the water or to the weather is proving to be durable and this has led many to believe that deterioration is due to some fault of the aggregate or cement instead of the porosity of the concrete. It is true that a great deal of the disintegration is

due to faulty materials, but there is much which is caused by too much mixing water. The porous structure allows chemical changes to take place within the interior of the concrete and attack on the concrete may take place to a certain extent throughout the entire mass. The writer proposed a void test as a means of predicting what will happen to concrete, and it is believed that some such test will eventually come into use after it is finally proven that remedies such as the water-cement ratio and the addition of admixtures do not entirely solve the problem of concrete deterioration.

#### Possible Improvements in the Manufacture of Cement

In view of the research work now under way on portland cement, perhaps little should be said about possible improvements in the quality of cement. Certainly some improvements can and will be made. Based on the writer's experience with concrete, several things suggest themselves. These suggestions, however, should not be incorporated in specifications without further study and full consideration of what they will mean to the manufacturer.

**The Sodium and Potassium Content Should Be Limited.** It is believed that the sodium and potassium content of cement should be limited, perhaps to less than 0.4 per cent of sodium and potassium oxides. Hereafter reference will be made only to sodium, but it is intended to include both compounds. If limiting the sodium did nothing more than reduce the unsightly efflorescence on concrete it would be well worth the expense. Cement is not something where the addition of a cent or two per bag will cause some other material to be used in its place. It is not believed that a material increase in price will cause other materials to take its place to any great extent. In fact, the deterioration and unsightly appearance of much of the concrete now being manufactured is going to hurt its use more than anything else. Concrete is now prohibited or is not used in certain parts of some structures largely because the appearance may be unsightly after a few years.

The compounds of sodium are believed to be of far more serious consequence than the production of the unsightly efflorescence. Most of the efflorescence found so abundantly on concrete surfaces in the spring of the year is sodium carbonate, but sodium sulfate is found occasionally. Frequently there is a mixture of the two. The presence of sodium carbonate indicates one stage of the concrete and sodium sulfate another. Sodium sulfate cannot pass through the pores of concrete containing the high calcium aluminates without having the  $\text{SO}_3$  ions unite with the calcium aluminates, unless the aluminates have already united with all the  $\text{SO}_3$  they will take up.

There is no positive proof, yet it seems probable that the sodium may be instrumental in hastening the transfer of sulfates to the interior of the concrete in some instances. Take the case of concrete exposed to rains. While the water is drying out of the concrete, sodium is being transferred by the water travel from the interior to the surface where it frequently concentrates to the point of crystallizing on the outside surface. If it is present as the hydroxide or carbonate, the sulfates near the concrete surface that have been released from the high calcium cement compounds by carbonization combine with part of the sodium. Sodium sulfate is very much more soluble than calcium sulfate, and when there is a rain the first water that strikes the concrete rapidly dissolves the sodium compounds and the solution is then transferred to the interior by capillary attraction.

When sulfates are present, the  $\text{SO}_3$  goes into chemical combination with the high calcium aluminates if any are

present within the interior of the concrete. The alternate wetting and drying of concrete exposed to rains tend to keep throwing the soluble compounds back into the concrete instead of washing them away. Consequently anything picked up by these soluble compounds near the surface that will unite with the high calcium cement compounds, such as  $\text{SO}_3$  and  $\text{CO}_2$ , may be transferred to the interior much more rapidly than if no sodium were present. The reduction of the  $\text{SO}_3$  ratio to that of calcium in the surface of some of the concrete which has carbonated, and the increase in this ratio within the interior is very good evidence that transfer has occurred. It is only concrete made from aggregates free from calcium that this condition can be tested. The sodium compounds also tend to dissolve some of the silica and alumina, which is shown in Table IV.

TABLE IV  
*Soluble Silica and Alumina in a Solution  
Containing Sodium Carbonate*

| Sodium Carbonate<br>in Solution | Per<br>Cent of $\text{Al}_2\text{O}_3$<br>in Solution | Per<br>Cent of $\text{SiO}_2$<br>in Solution |
|---------------------------------|-------------------------------------------------------|----------------------------------------------|
| Nearly saturated                | 0.30                                                  | 0.29                                         |

This is not a very high percentage of soluble alumina and silica, but any that goes into solution is probably in the direction of weakening the concrete. In addition to this, most of the sodium salts crystallize with a tendency to expand and disintegrate the concrete. Calcium carbonate apparently can crystallize within the pores of concrete with no tendency to expand it, but this is not the case with sodium carbonate and sodium sulfate. The continued efflorescence of sodium carbonate or sodium sulfate, either on brickwork or on concrete eventually causes disintegration. So far as is known sodium does no good in cement, and it is known to do enough harm to warrant considerable expense in removing as much as is possible.

**Should the Alumina and Calcium Sulfate Be Reduced?** The desire to produce concrete of high early strength possibly is responsible for the manufacture of cement that is not very durable under certain conditions of exposure. Fine grinding of cement, which is apparently one essential for producing high early strength, produces a greater surface of the cement particles for a given weight of materials. This means that the finely ground cement will have a greater proportion undergoing initial reaction with the mixing water. Covering the surface of all the particles with a precipitated film produced by the reaction of the  $\text{SO}_3$  and the high calcium aluminates to retard the rapid initial set requires more  $\text{SO}_3$ . To produce concrete that sets or hardens fairly rapidly for the first few days, it is necessary to keep the alumina content fairly high and to grind reasonably fine.

It has been shown that the high calcium aluminates are the more active compounds in concrete, yet it is not known if the alumina content can be reduced without detriment to the strength. If reducing the alumina would increase the durable qualities to a material extent but would also decrease the early hardening rate and the final strength, then more may be lost than gained by the change.

There is need for a vast amount of research work along this line. It is believed that reducing the alumina, grinding coarser than is now customary, and reducing the  $\text{SO}_3$  would produce more durable concrete for some conditions of exposure, but would we be justified in making such changes if it reduced the strength, which it undoubtedly will do, when perhaps two-thirds of the total concrete now being manufactured is protected or in structures not

(Continued on Page 49)

# Effect of Hydrated Lime in Concrete

## Some Experiences in Placing Concrete on the Wacker Drive in Chicago—Test Results

By R. W. PRIEST

Field Testing Engineer, Wacker Drive, Board of Local Improvements, Bureau of Design, City of Chicago

A CERTAIN degree of skepticism is often expressed by engineers and contractors as to the real advantage to be gained by the use of an admixture in concrete. Questions as to the relative effect on strength, absorption, permeability, density and workability of concrete with and without an admixture often arise. As Field Testing Engineer for the City of Chicago, on the Wacker Drive, the writer has had exceptional opportunity to study this question from actual laboratory and field tests.

Hydrated lime was used as an admixture in approximately 60 per cent of the 120,000 cubic yards of concrete in this project. The exception was that lime was not used in the concrete placed below ground, such as in caissons, subgirders, tie beams and pavement foundations.

The concrete on this project was for the most part of a nominal 1:2.33:3.67 mixture or a specified 1:6 proportion. It was the primary object of those in charge to obtain a concrete which would be uniform throughout the entire project and which would forever withstand river front exposure. It was necessary that the concrete be as nearly watertight as possible and of greater strength than the usual concrete of this classification. Therefore, using the fineness modulus method of combining aggregates, together with a system of water control and the use of 8 per cent of hydrated lime as an admixture with tested cement, we believe the mixture produced to be exceptional and of a nature suitable for a comparative test.

In selecting the aggregates, thought and care was taken in selecting those which would be delivered in the most uniform sizes. From actual sieve analysis throughout the job it was found that the average fineness modulus of the coarse aggregate was 6.84 and for torpedo sand was 2.86, with a variation of only a few points either way from the average at any time. Number 2 limestone was used for the most part and torpedo sand of a good grade, of 0 to 4 size, was specified. The sand inundator was

specified and used and the total water allowance was 7 gallons per sack of cement. Each batch of concrete was mixed 1½ minutes in rotary batch mixers and the mixed concrete was handled in such a manner as to eliminate segregation, its final deposition being from concrete buggies.

### Test Cylinders

From the 120,000 cubic yards of concrete in Wacker Drive approximately 6,000 6x12-inch test cylinders were made, or one from every 20 cubic yards of concrete poured. These field cylinders were made at regular intervals and are representative of the concrete as a whole, both with and without the admixture of hydrated lime. The field specimens were tested for compressive strength at various ages up to one year. Seven days, 14 days, 21 days, 28 days and one year respectively were the ages at which these tests were made. Additional specimens were tested for absorption and permeability.

The results of the tests are now available and it is now possible to make an interesting comparison between the concrete without admixture and the concrete containing 8 pounds of hydrated lime per sack of cement.

A careful study has been made of the compressive strength of 1000 representative cylinders taken over a period of two years. These cylinders are representative of identical mixtures and identical curing conditions. They were cured in damp sand in the laboratory at 70 deg. F. and tested for compressive strength in a 200,000 pound Riehle testing machine, these details being necessary for a fair comparison. Table I shows the results of the tests.

In a test to determine the effect of the addition of lime on the absorption of concrete, it was found that those cylinders containing the admixture absorbed an average of 3.23 per cent of water by weight during an immersion

TABLE I

| No. of Cylinders                       | —MIX—     |                 | —MATERIALS— |                 |                  |                   |                    |                |                   |            |            |          | —6x12-in. Concrete Cylinders— |                  |                                        |                                         |                                        |
|----------------------------------------|-----------|-----------------|-------------|-----------------|------------------|-------------------|--------------------|----------------|-------------------|------------|------------|----------|-------------------------------|------------------|----------------------------------------|-----------------------------------------|----------------------------------------|
|                                        | Specified | Actual          | —Cement—    |                 | —Fine Aggregate— |                   | —Coarse Aggregate— |                | —Concrete—        |            | Ave. Slump | Sec. Mix | Average Compressive Strength  |                  |                                        |                                         |                                        |
|                                        |           |                 | Brand       | Sacks per Batch | Kind and Size    | Cu. Ft. per Batch | Ave. F. M.         | Kind and Size  | Cu. Ft. per Batch | Ave. F. M. |            |          | Gals. Water Batch             | Method of Curing | Unit Load, Lbs.<br>per sq. in., 7 days | Unit Load, Lbs.<br>per sq. in., 28 days | Unit Load, Lbs.<br>per sq. in., 1 year |
| CONCRETE WITHOUT HYDRATED LIME         |           |                 |             |                 |                  |                   |                    |                |                   |            |            |          |                               |                  |                                        |                                         |                                        |
| 250                                    | 1-6       | 1/2.33<br>/3.67 | Universal   | 6               | 0-4<br>Tor.      | 14                | 2.86               | No. 2<br>Stone | 22                | 6.84       | 42         | 4        | 90                            | Damp<br>Sand     | 1632                                   | —                                       | —                                      |
| 250                                    | 1-6       | 1/2.33<br>/3.67 | Universal   | 6               | 0-4<br>Tor.      | 14                | 2.86               | No. 2<br>Stone | 22                | 6.84       | 42         | 4        | 90                            | Damp<br>Sand     | —                                      | 3176                                    | —                                      |
| 10                                     | 1-6       | 1/2.33<br>/3.67 | Universal   | 6               | 0-4<br>Tor.      | 14                | 2.86               | No. 2<br>Stone | 22                | 6.84       | 42         | 4        | 90                            | Damp<br>Sand     | —                                      | —                                       | 4362                                   |
| CONCRETE WITH 8 PER CENT HYDRATED LIME |           |                 |             |                 |                  |                   |                    |                |                   |            |            |          |                               |                  |                                        |                                         |                                        |
| 250                                    | 1-6       | 1/2.33<br>/3.67 | Universal   | 6               | 0-4<br>Tor.      | 14                | 2.86               | No. 2<br>Stone | 22                | 6.84       | 42         | 3½       | 90                            | Damp<br>Sand     | 1720                                   | —                                       | —                                      |
| 250                                    | 1-6       | 1/2.33<br>/3.67 | Universal   | 6               | 0-4<br>Tor.      | 14                | 2.86               | No. 2<br>Stone | 22                | 6.84       | 42         | 3½       | 90                            | Damp<br>Sand     | —                                      | 3214                                    | —                                      |
| 10                                     | 1-6       | 1/2.33<br>/3.67 | Universal   | 6               | 0-4<br>Tor.      | 14                | 2.86               | No. 2<br>Stone | 22                | 6.84       | 42         | 3½       | 90                            | Damp<br>Sand     | —                                      | —                                       | 4630                                   |

of 96 hours. The specimens without the lime gave an average absorption of 4.126 per cent with the same time of immersion. The cylinders were 28 days old and were of a nominal 1:2.33:3.67 mixture. They were the regular field specimens and were mixed and handled as previ-

of the yield of concrete when an admixture is used, a series of laboratory tests were conducted which demonstrated that the use of 8 per cent of lime did not give an increase, but rather resulted in a slightly less volume of concrete than when it was omitted.



□□□

*120,000 yards of quality controlled concrete were placed in Wacker Drive. 6,000 test cylinders were made from this concrete for studies described in this article*

□□□

□□□

*Workability was an important item in placing concrete in the heavily reinforced roadway slabs*

□□□



ously described.

The investigation also included penetration tests which were made on disc specimens 8 inches in diameter and 2 inches thick, 28 days old at the time of the test. Ten square inches of the faces of these discs were subjected to a water pressure of 22 pounds per square inch for a period of 72 hours. The discs containing no admixture permitted the passage of 15 per cent more water than those containing hydrated lime. Table II shows the results of these tests:

| Spec. No.        | Mixture | Kind and Size of Material        | Without Lime C. C. Permeating Spec. A. | With 8% Lime C. C. Permeating Spec. B. | Per Cent Difference |
|------------------|---------|----------------------------------|----------------------------------------|----------------------------------------|---------------------|
| No. 1<br>A. & B. | 1:2     | No. 4 & 5 Granite Screenings 0-4 | 425—C. C.                              | 376—C. C.                              | 13.6                |
| No. 2<br>A. & B. | 1:3     | Torpedo                          | 572                                    | 490                                    | 16.7                |
| No. 3<br>A. & B. | 1:4     | No. 4 & 5 Granite Screenings 0-4 | 642                                    | 555                                    | 15.6                |
| No. 4<br>A. & B. | 1:5     | Torpedo                          | 681                                    | 604                                    | 12.6                |

#### Yield Tests

In order to settle to our own satisfaction the question

## Relation Between the Characteristics of Portland Cement and Deterioration of Concrete

(Continued from Page 47)

intended to last very long? It may be best to let the cement stay as it is insofar as the main constituents are concerned and try to protect the portions of the concrete that will be subject to deterioration.

The use of concrete should be discouraged where it is known that deterioration cannot be avoided. There are not many instances, however, where it cannot be made durable if proper precautions are taken. Give concrete a fair chance to resist the agencies tending to destroy it and most of it will live up to the slogan, "Concrete for Permanence."

(The End)

### Accepts Chairmanship

Dr. Esteban Gil Borges, Assistant Director of the Pan American Union, has accepted the chairmanship for Pan-American Day at the 1928 Road Builders show at Cleveland, on January 9th to 13th.

# The A. B. C.'s of Good Concrete

## Some of the Factors That Affect the Quality of Concrete —Thorough Mixing Increases Strength and Makes Concrete More Workable—More Uniform Concrete Made When Longer Mixing Time Is Used

### Part VI.—Thorough Mixing Pays

THE general requirements for making good concrete—selection of proper aggregates, using the least amount of mixing water, methods of selecting the mix and proper curing—have been discussed in previous chapters in this outline of how to make good concrete. If these simple requirements are met, good concrete will result.

It is not necessary to get out the slide rule and the logarithm tables to find a method of making good concrete. It is a simple process. All that is required is a reasonable amount of care, as shown in these articles.

While we are talking about good concrete, it is worth while to look at some other helps that have not yet been discussed in these chapters. One of them is the effect of thorough mixing, which is the subject of this month's chapter. Future chapters will bring up other questions.

WHEN a contractor takes a contract for placing a certain volume of concrete, he naturally wants to get the concrete into the forms as quickly as possible. Sometimes his enthusiasm to do this leads to difficulties. He is liable to neglect the important item of thorough mixing. Two batches per minute from a mixer gives a rapid output, but it has a bad effect on the concrete.

The more up-to-date concrete specifications have very definite provisions regarding the length of time a batch of concrete is required to be in the mixer. A full minute, from the time the last materials are put into the drum until the first concrete is taken out, is the minimum requirement. Many specifications require a minute and a half and some require two minutes actual mixing time.

Output can be maintained by the contractor by using larger mixers and by organizing his crews so that the least amount of time is needed in charging and discharging the mixer. Then, too, the contractor or the products manufacturer who insists on thorough mixing has found that other benefits such as increased workability, greater strength and greater uniformity of quality result from thorough mixing. These qualities have a dollar and cents value to the contractor. Concrete that has not been thoroughly mixed is liable to contain stone pockets or voids which are often a source of additional expense to the contractor.

There are two reasons for mixing concrete; first, to bring the water in contact with every particle of cement and, second, to bring about a thorough combination of materials in which the materials are evenly distributed throughout the entire batch.

These two operations may be performed at the same time as in most outside concrete work or separately as is usually done in product plants.

Mixers in general use are of two types, those with rotating drums with fixed blades, known as batch mixers and usually used on outdoor work; and those with stationary drums and rotating blades often used in products plants.

#### How Mixing Affects Concrete Strength

Some interesting tests on the effect of mixing time on the strength of concrete have been made. The curve shown in Figure 1 illustrates the fact that longer mixing increases strength. Notice the rapid increase in strength during the first two minutes.

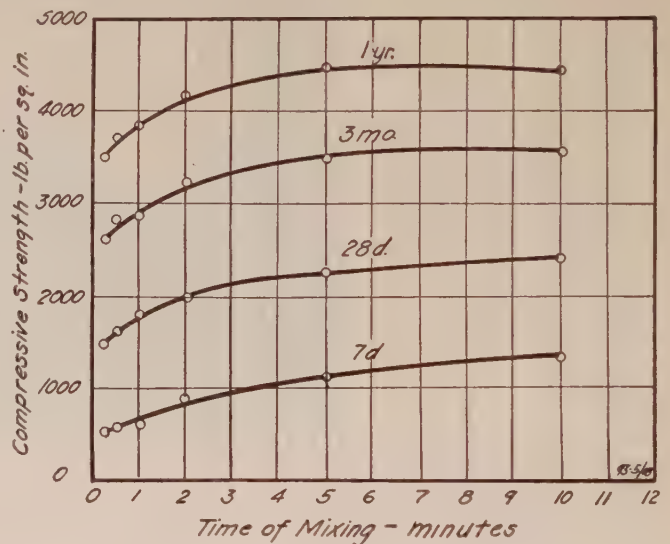


Fig. 1

The same tests, presented in the form of the following table, indicate the benefits of thorough mixing very clearly.

| MIXING TIME, MINUTES | STRENGTH SECURED FOR A 1 MINUTE MIX |
|----------------------|-------------------------------------|
| $\frac{1}{4}$        | 80                                  |
| $\frac{1}{2}$        | 90                                  |
| 1                    | 100                                 |
| 2                    | 110                                 |
| 5                    | 122                                 |
| 10                   | 130                                 |

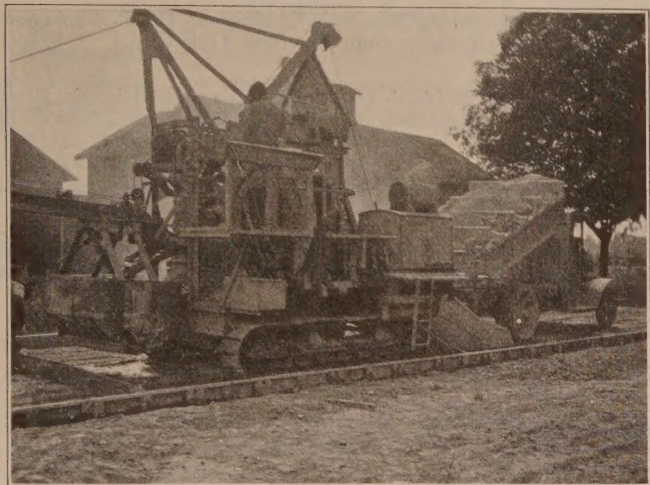
These results can be considered as only approximate because it is reasonable to believe that there may be some variation with different types of mixtures.

Increasing the mixing time from  $\frac{1}{4}$  minute to two minutes will increase the strength of the concrete 30 per cent. Five minutes mixing will bring still further increase in strength, but this length of time is, of course, greater than is practicable. But a mixing time of from one to

two minutes after all the materials, including the water, are placed in the drum is practical and ought to be insisted upon by every concreter who is aiming at quality concrete.

Products manufacturers have found that best results are obtained when the materials are first mixed dry for a period of not less than  $1\frac{1}{2}$  minutes and then for an additional 2 to 5 minutes after the water is added.

The relatively dry mixes and fine aggregates used in



*There is an increase of 30 per cent in strength between  $\frac{1}{4}$  to 2 minute mixing*

the tamping and pressure processes of concrete products manufacture make longer mixing advisable. The additional workability is a decided advantage in wet cast processes also.

Usually the products plant mixer can turn out concrete faster than is needed in the plant, and the concrete can be mixed for longer periods without cutting down production.

### Effect of Speed of Mixer Drum

Figure 2 illustrates the effect of changing the speed of the mixer drum on the strength of the concrete. It will be seen that changes in speed of the mixer from 12 to 25 revolutions per minute have little effect on the strength of the concrete. It is therefore evident that speeding up the mixer will not take the place of length of mixing time. The number of revolutions of the mixer drum is not a substitute for the length of time that the concrete is in

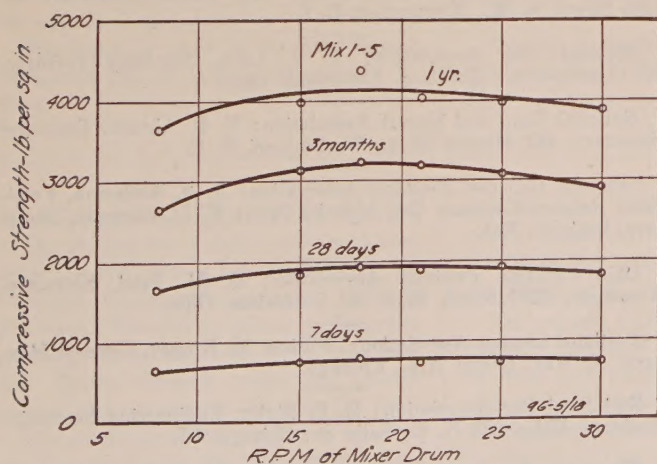


Fig. 2

the mixer. It is *time* of mixing, not *speed* of mixing that is the important item.

In the 1924 Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete, the following requirements for mixing were suggested. "The mixing of each batch shall continue not less than one minute after all the materials are in the mixer, during which time the mixer shall rotate at a peripheral speed of about 200 feet per minute."

### How the Contractor Benefits

The assurance of stronger concrete with thorough mixing operates to the advantage of the contractor, especially when he is working under the water cement ratio specifications in which concrete of certain definite strengths is the principal requirement. The fact that thorough mixing also makes much more uniform concrete is of interest to the contractor. Specimens of concrete mixed for only fifteen seconds showed an average variation in strength of 30 per cent, while specimens made of concrete mixed for two minutes varied only 10 per cent.

Workability is also increased by longer mixing and this quality has a definite bearing on the cost of placing the concrete. Concretors who have lengthened their mixing time have found that not only did they place better concrete than ever before but the concrete was easier to



*Cost is definitely dependent upon workability and every fraction of increased mixing time increases strength*

handle and the total time required for the job was not increased.

When mixer output is speeded up by cutting down mixing time, the gain to the job as a whole is not as great as is sometimes expected. The spurt is usually followed by a period when the mixer is idle while materials are being measured and placed in the skip. Studies made by contractors themselves have shown that the best way to increase mixer output is to cut down the idle time when the mixer is not operating between batches.

### Some Precautions

Be sure that each batch is completely emptied from the mixer drum before recharging. Hardened concrete that often sticks to the inside of the mixer drum should be removed at intervals during the day when the mixer is shut down for any reason. The mixer should always be thoroughly cleaned at the end of the day's run. Never re-mix concrete that has partially hardened.

# Mixer Musings

Reported by "Joe"—The Mixer Boss.

## Listen to Bragg Bragging

Dear Joe:

**M**Y first experience with a really remarkable slump occurred in 1907. I had been acting as valet to some of those old fashioned 8 x 16 in. concrete cylinders which were quartered on the premises of the old Technologic Branch of the Geological Survey at St. Louis. I used to dress them up real nice with plaster of Paris caps and a coat of armor known as a compressometer.

We had quite a large stable of cylinders all sired by Richard L. Humphrey and dammed by myself and others. One day along toward the middle of March, 1907, "Dick" called the stable help in and told us we had been partially instrumental in spending all of the governments' ready cash and unless he managed to get an emergency appropriation, we would receive no pay after the first of March. To receive such news in the middle of March was bad but to receive it at all in 1907 was worse, because that was the year of John Smith checks and soup houses.

Well, R. L. didn't connect with the emergency appropriation. Uncle Sam needed the money for the Congressional Library and free seeds. Besides, concrete wasn't so important then. We knew the disastrous effect of excess water but the Guild of Slumpers had not yet passed the W/C Ratio prohibition law. To make a long story short, the slump lasted from March 1 to July first, when we received our regular appropriation and went back on the payroll.

Those of us who had donated our services from March 1 to April 15 in order to herd the cylinders through the teething period to maturity, received a substantial increase in salary. As I recall it my salary was increased from fifty to sixty-five dollars per month and I jumped from Laboratory Apprentice to Laboratory Assistant as easy as that. Now don't laugh, Joe, that was twenty years ago and a 30 per cent increase in salary meant just as much then as it would now if you knew how to get one.

Since that time I have made slumps here, there, and everywhere. We made standardized slumps in the Pittsburgh branch of the Bureau of Standards and ordinary slumps in the New Jersey Highway Dept. We had a slump "can" on every job and some of them were used, too. I have made slumps, I have been slumped and I have known times when I could hardly pass a chair without slumping on it.

And speaking of slumps in general, you know very well, Joe, that slump or no slump, when you dump a properly mixed batch from the mixer and it does the "black bottom" i. e., it doesn't stand still and it doesn't go some place in a hurry; that's concrete. That is also a true measure of workability.

Do I get in?

(Signed)

J. G. Bragg

Service Engineer, Alpha Portland Cement Co.

*Looks like we can't help but let you in, Bragg.*

## To All the Slump Testers Who Wrote in the Last Few Days:

The boss has gone and promised me a bigger office force soon, and as soon as I get it, I'll acknowledge your applications.

**Joe**, the Mixer Boss.

## Organizations

American Concrete Institute; Harvey Whipple, Secretary, 2970 West Grand Blvd., Detroit.

American Concrete Pipe Association; M. W. Loving, Secretary, 33 W. Grand Ave., Chicago.

American Construction Council; Dwight L. Hoopingarner, Executive, 28 W. 44th St., New York City.

American Engineering Standards Committee; Dr. P. G. Agnew, Secretary, 29 West Thirty-ninth St., New York City.

American Road Builders' Association; Chas. M. Babcock, President; Miss E. A. Birchland, Secretary, 29 W. 39th St., New York City.

American Society of Civil Engineers; Geo. T. Seabury, Secretary, 33 W. 39th St., New York City.

American Society for Testing Materials; C. L. Warwick, Secretary-Treasurer, Engineers' Club Building, 1315 Spruce St., Philadelphia, Pa.

Associated General Contractors of America; D. H. Sawyer, Secretary, 1150 Munsey Bldg., Washington, D. C.

Associated Metal Lath Manufacturers; 123 West Madison St., Chicago; Wharton Clay, Commissioner.

Building Officials Conference of America; H. E. Plummer, President; Fred W. Lumis, City Hall, Springfield, Mass., Secretary.

Concrete Reinforcing Steel Institute; M. A. Beeman, Secretary, Tribune Tower, Chicago.

Concrete Products Association; S. I. Crew, President, Norwood, Ohio; Austin Crabbs, Secretary, Box 343, Davenport, Iowa.

Iowa Concrete Products Association; Floyd Goodrich, President; R. L. Gavin, Secretary-Treasurer, 405 Hubbell Bldg., Des Moines, Iowa.

National Association of Building Trades Employers; A. E. Coleman, President; A. W. Dickson, Executive Secretary, 2226 Builders Building, Chicago, Illinois.

National Association of Builders' Exchanges; William F. Chew, Baltimore, President; Earl F. Stokes, Secretary, 15 East Fayette St., Baltimore, Md.

National Crushed Stone Association; J. R. Boyd, Secretary, 751 Earle Building, Washington, D. C.

National Housing Association; Lawrence Veiller, Secretary and Director, 105 East Twenty-second St., New York City.

The National Lime Association; G. B. Arthur, Secretary, 927 15th Street, N. W., Washington, D. C.

National Slag Association; H. J. Love, Secretary-Treasurer, 933 Leader-News Building, Cleveland, Ohio.

National Sand and Gravel Association; V. P. Ahearn, Executive Secretary, 432 Munsey Bldg., Washington, D. C.

Nebraska Concrete Products Association; A. V. Anderson, President, Reimers-Kaufman Co., Lincoln, Neb.; E. L. Bateman, Secretary, Bethany, Neb.

Ohio Concrete Products Association; G. M. Friel, Secretary-Treasurer, 2284 North High St., Columbus, Ohio.

Portland Cement Association; William M. Kinney, General Manager, 33 West Grand Ave., Chicago.

Rail Steel Bar Association; H. P. Bigler, Engineering Secretary, Builders' Bldg., 228 N. La Salle St., Chicago, Ill.

Wisconsin Concrete Products Association; A. P. Kuranz, Secretary-Treasurer, 425 E. Water St., Milwaukee.

# New Equipment

## Littleford Heaters for Tilting and Non-Tilting Mixers Easily Installed

Kerosene-burning concrete heaters suitable for mounting on any make or size of mixer are now being offered by Littleford Bros. of Cincinnati, Ohio. Included are units for application on either tilting drum mixers or non-tilters.

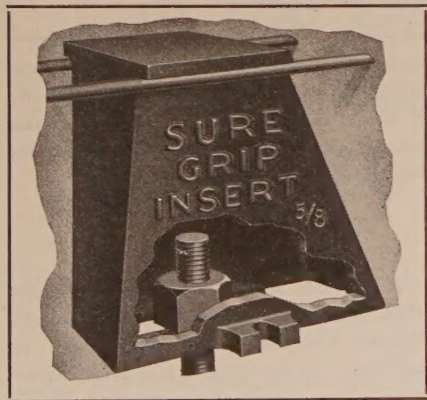
No additional labor is required as the man who operates the mixer also operates the heater. The unit consists of a torch

type oil burner of proper size, depending on capacity of mixing drum, with fuel tank, oil hose, necessary fittings, elbow flame deflector, and band for attaching to mixer. Installation is simple.

A valve adjustment regulates the flame to any desired size. Windshield on burner assures perfect operation under all weather conditions.

## Sure Grip Insert Is Wedge Shaped

The Sure Grip Concrete Insert, a product of the Dayton Sure Grip & Shore Company, Dayton, Ohio., is made of certified malleable iron, designed to permit a horizontal as well as vertical adjustment in insert.



Its wedge shape construction takes advantage of the holding strength of concrete, both compression and direct shear and will carry with a large factor of safety the safe load of bolt.

The insert is made for  $\frac{1}{2}$ -inch,  $\frac{5}{8}$ -inch or  $\frac{3}{4}$ -inch bolt, or  $\frac{1}{4}$ -inch,  $\frac{3}{8}$ -inch and  $\frac{1}{2}$ -pipe.

## 30 Colors of Concrete Units

The process for a new, color-fused concrete masonry unit is being offered by the Concrete Equipment Company, Holland, Michigan. The unit is known as Texcrete, and is produced as block, brick or hollow tile. Thirty different colors and shades of mat glaze are made available.

The color-fusing has become a part of the Texcrete plant. The plain cured units are placed in a row or on a truck. The

## "Stainproof" Protects Floors From Ravages of Workers

The Master Builders Company, Cleveland, Ohio, has made announcement of a new method and material to cope with the indelible evidences of their occupancy that painters, plasterers and workers at other similar trades leave behind them on new terrazzo and tile floors.

The material is called Stainproof and is a jelly-like substance specially prepared for application to new cement surfaces. It is applied to the surface in a paint-like coat 36 hours after the final troweling. It dries to form a non-porous, viscous film through which paint, plaster and similar staining agents cannot penetrate. Over this film workers complete their job. Equipment may be moved in and set up.

When the building is ready for occupancy, the Stainproof film is removed, disclosing a clean, unmarred floor.

Proper curing has been abetted by the film, which allows slow and correct curing of the cement, a step toward the prevention of efflorescence and reduction of crazing.

One of its early applications is in the new building of Walker & Weeks, Cleveland architects.

color-fusing material is then quickly shot on by compressed air. After curing for a few days, the units are delivered directly to the job.

The simple outfit and the color-fusing material furnished insure uniform results in color and texture. It is said that the unit and the surface treatment become so closely united that the fused finish cannot be broken or chiseled without injuring the unit.

## Milcor Metal Lath Shears Cut Without Crushing

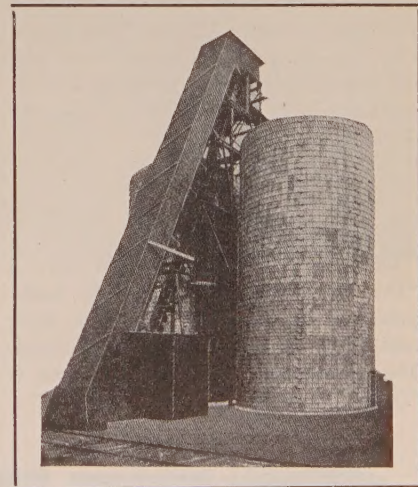
A one-man shears, for cutting Milcor  $\frac{3}{4}$ -inch Stay-Rib No. 3 Metal Lath, without crushing or injuring the metal, has been designed by the Milwaukee Corrugating Company, Milwaukee, Wisconsin.

The cutting surface is the same width as the lath. A sheet of Milcor Stay-Rib No. 3 concrete reinforcing metal lath is placed in the machine and measured off for the desired length, the handle is pulled and a straight, uniform edge will be cut the entire width of the sheet.

The shears, which are designed to cut Milcor  $\frac{3}{4}$ -inch Stay-Rib Metal Lath No. 3 only, may be rented or purchased.

## Besser Concrete Silo Bins Have Wide Range of Capacities

The Besser Sales Company, Monadnock Building, Chicago, Illinois, is now prepared to sell standard concrete silo bins in practically any desired height, diameter and carrying capacity. They are sold erected on the job, at a cost said to be about one-third of that of other materials. Diameters in even numbers from 10 to 24 feet, with any height up to 60 feet, are available.



A safety factor of 6 to 1 permits the carrying of penthouses directly on top of the bins. Crushers and screens may be mounted directly over the bins. Any desired slope of the bottom may be secured. A patented gate, designed to provide easy operation with positive action and rapid discharge, is furnished with each bin.



# With the Manufacturers



## INDUSTRIAL LITERATURE

### "Conco" Crane Catalog

A new catalog, *No. 100*, published by *H. D. Conkey & Company*, gives complete crane and trolley specifications, clearances, and list prices. An effort was made in its compilation to feature, in a complete way, lighter capacity cranes.

### Paint Shooting

All manner of spray gun applications are represented in the finishing room equipment *Catalog FX*, published by the *DeVilbiss Company*, Toledo, Ohio. Outside of the finishing of portable products, some space is devoted to stationary spray painting.

### Super Cement Booklet

Almost any question that can be raised about *Vulcanite Super Cement*, its composition, manufacture and use, is answered in a 10-page booklet published by the *Vulcanite Portland Cement Company*, which has recently become one of the manufacturers of *Super Cement*.

### Pumping Handbook

Similar to the *Novo Hoisting Handbook* is the *Novo Pumping Handbook*, which is just being distributed by the *Novo Engine Company*, Lansing, Michigan. Much useful data on pumps and pumping work is contained in it. Problems of all sorts are discussed and illustrated.

### Truck Leaflet

Of interest to truck and hoist users is "*The Wood Hoister*," a four-page leaflet published by the *Wood Hydraulic Hoist and Body Company*, Detroit, Michigan. The feature item of the October issue is "Dump Trucks vs. Industrial Railways."

### Medusa Publications

"*The Medusa Farm Book*," is a new publication originated by the *Sandusky Cement Company*, Cleveland, Ohio. It is an attractively covered book, and has a complete range of contents.

New editions have been issued of the *Medusa White Portland Cement* book and the *Medusa Waterproofing* specifications.

### Lumnite in Winter

The *Atlas Lumnite Cement Company*, New York City, is distributing a brochure on winter concrete. Results of compression tests made by an eastern city are shown, as are also a dozen interesting views of winter construction.

Copies may be secured upon request.

### Catalog of Specialties

Building specialties that are a new product of the *Union Steel Products Company*, Albion, Michigan, are found in a 16-page catalog, *No. 227*. A variety of 15 building specialties is described. Attention is called particularly to the prespaced continuous units that facilitate handling and spacing of reinforcement and reduce costs.

### New Universal Catalog

The *Universal Form Clamp Company*, Chicago, has catalogued into attractive form all of its products that are classified as concrete building accessories. This is a 48-page book containing excellent illustrations of the items in use, specifications, diagrams, etc.

### Pallet Catalog

A 16-page catalog issued by the *Commercial Shearing and Stamping Company*, Youngstown, Ohio, deals exclusively with *Commercial* pallets, their design, use and features. Of especial interest is that page devoted to the trademarking of block by pallets, a method required by some building codes.

## Notes from the Field

### Concrete Products Supplies

The *H. H. Potts Company (Not Inc.)* has been organized and located at 228 North La Salle Street, Chicago, to make and distribute stucco dashes and concrete products surface finishes.

Special and standard stucco dashes, ornamental facing aggregates, Calatom, which is a diatomaceous earth used as an admixture, cement colors and cement paints, are the principal products.

### Dayton Suit Dismissed

The *Dayton Sure Grip and Shore Company*, Dayton, Ohio, wishes it to be known that the suit brought against it for infringement of patent by the *Bull-Dog Sleeper Grip Company*, Winterset, Iowa, two years ago, was dismissed by the plaintiff on October 1st.

### Western Distributors

The *Stuart S. Smith Company*, San Francisco, Calif., has been appointed by the *T. L. Smith Company*, Milwaukee, as distributors of *Smith* mixers and pavers for the northern California and western Nevada territories.

### New Marsh-Capron Office

*Marsh-Capron Company* announces the opening of a new office at 1601 Chestnut

Street, Philadelphia, and a new warehouse at *Primos* (Philadelphia suburb). *Mr. W. B. Patterson* is in charge as district manager of eastern Pennsylvania, southern New Jersey and eastern Delaware.

### Atlas Transfer

*J. H. Bell* has been appointed Pacific coast representative of the *Atlas Portland Cement Company*, New York City. He will have his headquarters in Los Angeles, with offices at 507 Edwards and Widely Building.

*R. H. Campbell*, formerly representing *Atlas* on the west coast, has been transferred to New York in charge of the white cement department.

### Hunt Office

The *Robert W. Hunt Company*, engineers and inspectors, announce that their Birmingham, Alabama, office is now located in the Bankers Bond Building.

### New Pipe Booklet

The *American Concrete Pipe Association*, Chicago, Illinois, has just completed the publication of a 32-page booklet divided into four sections, as follows: History of Sanitary Engineering, History of Concrete as a Sewer Building Material, Manufacture of Concrete Pipe, and Typical Cities Using Concrete Pipe.